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THE SKULL OF AN AUSTRALIAN ABORIGINAL FOUND AT STRADBROKE ISLAND, QUEENSLAND.

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(Text-figures 1 to 7 and Plates XV—XVIII.)

The skull, No. Q.E. 14/561, has been known as the Wynnum skull because the records show that it was brought to the Museum from Wynnum, a suburb of Brisbane. A search through official correspondence has, however, brought to light a letter which reveals that it was found on the beach at Jumpinpin on the east side of Stradbroke Island on the 28th May, 1914. Further information is contained in the letter that 20 years previously there were five graves in the vicinity of where the skull was found, but the sea broke over this part some years ago and washed the graves away, and made the channel at Jumpinpin, dividing Stradbroke Island.

A brief description of the skull was given by Longman (1918) in which he referred to its relatively large proportions for an Australian aboriginal. The skull is, however, definitely that of an Australian aboriginal and no further description would be warranted were it not for the fact that it has undergone a certain degree of mineralisation.

The discoveries of the Talgai skull and, later, of the Cohuna skull—both of which are clearly Australian—vaguely suggest from their state of mineralisation, and from what we know of their sites of discovery, that the aboriginal was an inhabitant of the continent for a long period of time. The geological age of the Talgai skull is somewhat uncertain ; but the considered opinion of S. A. Smith (1918), derived from the observations of Edgeworth David, is that "the claim to high geological antiquity—the assignation of the fossil to the Pleistocene—is very strongly supported, and may be regarded as established." The geological evidence for the age of the Cohuna skull has not been published but it would appear to be of later date than the Talgai skull.

Further evidence of the antiquity of man in Australia is provided by the excavations of Hale and Tindale (1930) in the Lower Murray Valley. These authors, by employing accurate methods of excavation, have established definite cultural layers in which human remains were found ; and have given to us for the first time a foundation on which to build up cultural sequences and to determine relative age groupings.

It is desirable, in the light of these findings, to place on record the morphological features of any human material which shows evidence of mineralisation in order that such information may be used for the purposes of confirmation and comparison with material which may be found subsequently.

Method.—The description of the skull is dealt with, firstly, by making an accurate survey of the various normae using the Frankfort plane as the base (figs. 1 to 6); secondly, by constructing a centimetre-contoured map on the Frankfort plane in order to give expression to the various slopes of the skull (fig. 7); and, thirdly, by the use of photographs to illustrate the non-metrical features (pl. xv, figs. 8 to 11, and pl. xvi, figs. 12 to 14). The photographs were taken by Mr. L. Schaeffer, of the Department of Anatomy, and to him I express my thanks. A brief description of the endocranial cast is also given.

By the use of the above methods the written description can be considerably curtailed. Detailed measurements of the skull are not given because those who find scientific satisfaction in their use can read off any desired measurements from the surveys. Three measurements are, however, of interest because they are unusual in the skull of the Australian aboriginal. The maximum length is 202 mms., the maximum breadth 140 mms., and the minimum frontal width 105 mms. The length is the same as that found by Duckworth (1894) in No. 2101 of his series; it is 2 mms. less than the skull recorded by Miklucho-Maclay (1883), and is only 2 mms. more than many of the skulls recorded by Turner (1884) and Klaatsch (1908). The maximum breadth and minimum frontal breadth are also above the average for the Australian. The skull is also unusually thick.

The Cranium. Norma verticalis (figs. 1, 7, and 8).—The skull, seen from above, has the form of a long ovoid, with the widest part of the skull situated 20 mms. posterior to the level of the external auditory meatus. Anteriorly the general outline is more sharply curved than it is posteriorly. The parietal eminence is not well marked on account of the general flatness of the lateral walls of the cranium. The slopes of the frontal region are uniform; and the frontal eminences have become smoothed out in the general outline. A typical Australian form is thus present in conjunction with a greater average size, which, however, is due is some measure to the excessive thickness of the skull.

Anteriorly the arci superciliares form two rounded projections extending from the midline to a point just lateral to the groove for the supraorbital vessels and nerve. Medially a well marked fossa supraglabellaris is present, whilst laterally the arci are smoothed off into the supraorbital trigones (fig. 3 *d*). Remaining traces of the coronal and sagittal sutures permit the identification of bregma.

Norma occipitalis (figs. 2 and pl. xv, fig. 9).—Viewed from behind the general contour presents a typical Australian facies. Laterally the side walls are flat and slope outwards very slightly as they extend from the mastoid processes to the parietal eminences. The superior surface, extending from the parietal eminence to the middle line, is flat to slightly concave. There is a slightly raised and rounded keel in the middle line. The whole appearance is very similar to that of the Australian depicted by Martin in fig. 370 (1928).

The most salient feature of the posterior region is the well developed *torus occipitalis transversus*. The torus is 20 mms. wide and extends laterally on either side for a distance of 25 mms. as a prominent and uniform ridge. There is no external occipital protruberance, although there is a small roughened ridge passing downwards on the nuchal surface from its midpoint. The torus is not symmetrical. On the left side it forms a fuller curve than on the right side ; and therefore extends higher into the supraoccipital bone. At a distance of 20 mms. from the middle line the torus resolves itself into two ridges, an upper and a lower. The upper ridge represents the *linea nuchae suprema* and the lower ridge the *linea nuchae superior*. The condition is very similar to that described by Burkitt and Hunter (1922) in skull 792 of the Sydney University series ; but the torus is more pronounced in the Stradbroke skull. The upper ridge fades away anteriorly in a large flat triangular area situated behind the superior temporal ridge on the postero-inferior angle of the parietal bone. The lower ridge retains its prominence and passes uninterruptedly into the mastoidal crest. The region between the torus occipitalis and lambda is raised into a planum occipitale, which is a common feature of the Australian skull.

The sutures in the region of asterion are still open ; but midway between asterion and lambda the upper part of the lambdoidal suture becomes obliterated. The condition of the closure of the sutures indicates that the age of the individual was between 60 and 70, basing the estimation on the work of Wingate Todd and Lyon (1925).

On the inner surface of the occipital region the groove for the transverse sinus is placed at a lower level than the torus occipitalis (fig. 5)—a condition commonly found in the skull of the Australian—Klaatsch (1908), Burkitt and Hunter (1922).

Norma frontalis (fig. 3 and pl. xv, fig. 10).—The whole of the facial skeleton is missing. Seen from the front the most salient features are the form of the supra-orbital region and the width of the anterior frontal region. The minimum frontal diameter measures 105 mms., which is unusually great for the Australian.

The supraorbital region shows a moderate degree of prominence in well developed superciliary eminences. It conforms to type 11 of Cunningham (1908) in

which the superciliary ridge coalesces with the part of the supraorbital ridge which lies medial to the supraorbital notch. On the outer side of the notch the *superciliary eminence* or ridge (*b*) extends outwards and fades into the flattened *supraorbital trigone* (*d*). On the inner side the superciliary eminence turns sharply under the glabellar region so that there must have been in this skull a very depressed root of the nose. Unfortunately there is no trace of either a fronto-nasal or fronto-maxillary suture. The glabellar region (*g*) is slightly depressed and extends upwards into a well marked *fossa supraglabellaris* (*s*).

The supraorbital region in this skull is almost identical with that of skull 340 of the University of Sydney series. There is, however, a significant difference between the Stradbroke skull and those which have been sectioned in the University of Sydney. Cunningham (1908), in discussing the relation of the superciliary eminence to the frontal air sinuses, referred to the fact that the extent of the air sinuses appeared to have no relation with the size of the superciliary eminence ; and, further, referred to the observation of Schwalbe (1901), that in the Neanderthal cranium the air sinuses lie well back and that a thick layer of condensed bone forms their anterior wall. Burkitt and Hunter (1922) found the maximum thickness of this condensed outer table to be 7·5 mms. at the glabella in skull 792.

In the Stradbroke skull the air sinuses are well developed (figs. 6 and 14) ; they are practically coincident in their extent with the superciliary eminences and extend also to the roof of the orbit ; but they differ from the other skulls in the Sydney collection in that the condensed outer table only measures 2 mms. as contrasted with 7·5 mms. in skull 792.

Norma lateralis (fig. 4 and pl. xv, fig. 11, pl. xvi, fig. 13).—The prominences produced by the torus occipitalis and arcus superciliaris are well shown when seen from the side. The torus occipitalis is clearly defined by the depressed nuchal area below and by the fossa supra-toralis above. The fossa supra-toralis is somewhat accentuated by the flattened surface of the supraoccipital region as high as lambda.

Although the mastoid processes are damaged on both sides it can be seen that they are of small size. On the left side, where only the tip of the process is lost, the mastoid process appears to confirm the opinion of Klaatsch (1908) that it is only the enlargement of the crista mastoidea (fig. 13). The crista mastoidea is continuous with the superior nuchal line and is here represented by a well marked ridge. The supramastoid crest—the continuation of the upper border of the zygomatic process —is separated from the mastoid crest by an interval of 30 mms. In many of the Australian skulls this interval is occupied by a furrow which passes to the postero-inferior angle of the parietal bone. In the Stradbroke skull there is no furrow on the

petrous part of the temporal bone ; but there is a definite depression where the anterior part of the postero-inferior angle of the parietal bone fits into the petro-squamosal angle. The region of the mastoid process conforms to the Australian type.

The inferior temporal crest passes continuously from the external angular process to the suprameatal crest. It is well defined throughout with only slight deformation where it passes the coronal suture. The temporal region bounded by this line is relatively flat. Anteriorly it is somewhat fuller than in the majority of Australian skulls, in harmony with the fact that its minimum frontal width is 105 mms.

The area of the skull above the temporal crest forms a continuous surface extending from the arcus superciliaris anteriorly to the torus occipitalis posteriorly. It is divisible into frontal, parietal and occipital sections. The frontal portion is somewhat full and rounded as far as the coronal suture ; so that the general form is smoothed off and there is no frontal eminence. In No. 752 and many other Australian skulls the frontal region immediately anterior to the coronal suture is depressed and flattened ; and in the majority of the Australian endocranial casts which I have examined there is a corresponding precentral depression of the frontal lobe. The precentral depression is a marked feature in the endocranial cast of the Wynnum skull. The full and rounded frontal region externally associated with a depressed frontal lobe internally is one of the most interesting morphological features of the skull. In the midline section of the skull (fig. 6) the bone is unusually thick ; at the torus occipitalis it measures 15 mms. ; above this it thins for a short distance to 7 mms., increasing again in the region of lambda—where the sutures are completely closed—to 14 mms. ; anterior to this the cranium in the mid-parietal region thins to 9 mms. to widen out again at bregma to 12 mms. ; and in front of this the thickness in the frontal region increases to 13 mms. The area of the frontal bone in which this thickness occurs extends laterally to include the whole of the frontal vault medial to the temporal crest. This thickening produces a flattened area of the inner table of the frontal bone which causes the precentral depression of the endocranial cast. The thickness of the skull exceeds that of any Australian skull which I have seen, and is slightly greater than that of the Piltdown fragments as determined from the casts.

Figure 15 shows the X-ray picture of the left side of the skull, for which I am indebted to my brother Dr. K. E. Shellshear. It shows two interesting stages in the age changes of the human skull. Harris (1933) has shown that after fifty the venous sinuses in the diploe gradually disappear, that new bone

is deposited in the diploe, and that the radiographic appearances change. Further, he refers to the laying down of dense new bone deposited between the dura and the inner table in old men at the site where there is atrophy of the frontal lobes. Now, in the radiographic picture of this skull the pattern of the diploic veins is well shown over the parietal area and over the lower part of the frontal area ; but at the borders of the thickened inner table of the frontal bone the diploic veins are disappearing and there are none over the thickness area itself. In dealing with the endocranial cast this question will be further discussed.

The parietal portion of the superior surface shows a depressed surface immediately posterior to the coronal elevation. This depression on the surface corresponds to the post-central area of ill-filling shown on the endocranial cast ; on this, however, it is more marked because the bone is somewhat thinner over the parietal eminence.

Norma basilaris (fig. 5 and pl. xvi, fig. 12).—The greater part of the base of the skull is missing. It is sufficiently described in the figures referred to above.

The endocranial cast (pl. xviii, figs. 16 to 19).—In the study of this cast I have the advantage of having for comparison a series of 25 casts of Australian skulls, as well as a large series of Chinese and most of the prehistoric casts of fossil skulls. The importance of the study of the endocranial cast is emphasised in the work of Elliot Smith ; and furthermore he has simplified the task of their examination by clearly setting out the principles involved. He writes (1926): " In approaching the study of the cast of the cranial cavity and attempting from it to interpret the nature of the brain that originally occupied a particular skull, our aims to-day are of a different nature than those of our predecessors. It is not so much the attempt to identify certain definite fissures and convolutions of the brain, as to determine the relative state of development of different functional areas of the brain. . . . . . . Hence the chief object is to base our conclusions not so much upon the size of any particular brain, as upon the relative size of those particular regions which are of significance in phylogenetics."

The distinctive features which distinguish the endocranial cast of *Homo sapiens* from those of lower types of human species are so clearly seen in this cast that no discussion is necessary on that aspect of the interpretation ; and so we may confine our attention to those features which distinguish the cast as Australian.

In prosecuting the task of determining the difference in the brain of race, I have collected the endocranial casts of 35 Chinese skulls, 25 Australian aboriginal skulls, and individual casts of other races. A study of this material makes it clear

that the features of the casts indicating racial difference enable one to distinguish racial difference with even more facility than the skulls themselves can be distinguished. The Chinese cast stands out with its large rounded frontal lobes bearing a foreshortened appearance, with its salient parietal eminences, its flattened and foreshortened occipital region, and finally with its cerebellum extending nearly as far posteriorly as the occipital pole of the cerebrum. Whereas, the Australian cast is recognised, amongst other things, by its narrowness accentuating its height, by its narrow and ill developed frontal lobes, and by the small amount of overhang of the cerebellum by the tentorial surface of the cerebrum.

The general form of the Stradbroke cast conforms to the Australian type. It is dolichocephalic, but the type of dolichocephaly differs from the European type in that the occipital region looks diminutive. Looked at from above the edges of the cerebellum project beyond the contour of the parieto-occipital region of the cerebrum laterally. The angle formed by the anterior border of the cerebellum with the inferior border of the temporal lobe is almost 75 degrees and indicates lack of development of the post-temporal (T) and parieto-occipital regions (PO). Immediately anterior to the parietal eminence there is a well marked post-coronal depression (PCD) corresponding with the postcentral and supramarginal regions of the brain. The post-coronal depression is a salient feature in the Australian casts, whereas in the Chinese casts the post-coronal region is almost without exception full and rounded. This post-coronal depression is well seen in the endocranial casts of *Homo rhodesiensis* and *Homo soloensis* and is associated with lack of development of the parietal areas of the brain. But, in attributing the depression to lack of development, the work of Keith (1931) on the effect of the streams and pools of cerebro-spinal fluid on the form of the cast must not be overlooked. Whatever the cause the presence of a post-coronal depression is common in the endocranial cast of the Australian. Immediately anterior to the post-coronal depression there is a fairly prominent coronal elevation (C) which widens out superiorly to blend with a wide sagittal elevation. In the majority of European and Chinese casts the transverse contour of the parietal region displays and even dome-shaped curve. Any irregularity in the curve above is limited to the size of the arachnoid granulations. In the endocranial cast of the aboriginal, however, the general transverse outline is more rugged. Passing along the vertex antero-posteriorly—and even extending forward into the frontal region—is a wide raised plateau lifted up from the general contour. The post-coronal depression ceases at its outer border superiorly and becomes continuous with a depression (P) in the parietal region which lies on the outer side of the plateau as far posteriorly as the parieto-occipital region. On the midline plateau there may be secondary

localised elevations corresponding to those seen in the European and Chinese casts produced by the arachnoid granulations.

The Stradbroke cast clearly demonstrates the features described above. The European and Chinese casts indicate the development of a higher type of brain in the filling up of the sagittal parietal depressions (P), bringing, as it were, the general outline to the level of the midline sagittal elevation.

The frontal lobe, looked at from above and anteriorly, shows a depressed area (F) lying in the angle formed by the coronal and mid-sagittal elevations. This depression of the frontal lobe is seen in most of the Australian casts and is very similar in appearance with the frontal depression seen in the cast of *Homo rhodesiensis*. In the Stradbroke cast, however, the depression is somewhat unusual in that markings for the sulci and gyri of the frontal lobe are not present over the depressed area. In most casts of primitive and modern races, whether a depression is present or not, the gyri and sulci of the frontal lobe leave some impression on the frontal lobe.

Harris (1933) has pointed out that " certain changes in the skull bones during old age seem to be determined by concomitant changes in the underlying brain," and that dense new bone is laid down between the inner table and the dura mater where senile atrophy of the frontal lobe has taken place.

The absence of cerebral markings on the frontal depression, the great thickness of the frontal bone, particularly in this area, and the advanced age of the skull all indicate that, whether a depression was present before the age changes took place or not, the frontal depression in the Stradbroke cast cannot be used as evidence for lack of expansion. Other evidence for lack of expansion is, however, present in the lack of fulness of the orbital margin (O) in the region of the inferior frontal gyrus and in the relatively well marked frontal keel.

The occipital region, looked at from behind (fig. 18), presents an appearance which is significant in determining its Australian status. The occipital poles are almost blended together in one large and rounded swelling standing out from the rest of the cerebrum. At no place does the contour of the parietal lobe run smoothly into that of the occipital lobe. The occipital lobe is everywhere separated by a salient parieto-occipital groove which passes from tentorial border to tentorial border. The prominence of the supra-occipital region—a feature of many Australian skulls—thus leaves its impression on the form of the endocranial cast. The projection of the supra-occipital region is not due to bony thickening but to the occipital projection of the brain ; and actually the midline section of the skull shows the skull to be thinnest in this region.

Above the occipital projection the surface slopes upwards to the midline sagittal plateau (fig. 18) bounded on either side by the parietal depression.

Below the occipital projection the cerebellum is unduly prominent and spreads laterally beyond the level of the parieto-occipital region. Thus undue prominence of the cerebellum, placed relatively far back, is an almost constant feature in the endocranial cast of the Chinese ; and is also seen in the cast of the Bushman D. 709 of the Museum of the Royal College of Surgeons. The cerebellum of the European cast, on the other hand, is, as it were, partly buried under the tentorial surfaces. The occipital region has the appearance of having spread out posteriorly and laterally and thus overflowing the boundaries of the cerebellum.

The relations of the cerebellum to the cerebrum cannot be attributed in the Australian to any retention of primitive features, because in *Sinanthropus*, *Pithecanthropus*, *H. rhodesiensis*, *H. neanderthalensis* and *H. soloensis* the position of the cerebellum accords with the European type. Furthermore, the condition in the Chinese is associated with a fairly high degree of brachycephaly and is also present in the only brachycephalic European cast which has been available.

The significant feature, then, in the Australian cast and in the cast of the Bushman D. 709 is that the undue prominence of the cerebellum is present in association with dolichocephaly.

DESCRIPTION OF FIGURES.

Figs. 1 to 6. Orthogonal projections of the dorsal, posterior, anterior, lateral, inferior and medial views of the skull. The skull was mounted in the Frankfort plane.

Fig. 7. A centimetre contoured map of the skull using the Frankfort plane as the base plane.

Pl. XV. Figs. 8 to 11. Photographs of the normae verticalis, occipitalis, frontalis and lateralis, respectively.

Pl. XVI. Figs. 12 to 14. Photographs of the normae basalis and lateralis and of the median section of the skull.

Pl. XVII. Fig. 15. X-ray photograph of the skull taken from the lateral aspect.

Pl. XVIII. Figs. 16 to 19. Photographs of the endocranial cast taken from the anterior, dorsal, posterior and lateral aspects.

C. coronal elevation, F. frontal depression, P. parietal depression, PCD. post-coronal depression,

PO. parieto-occipital depression, O. orbital elevation, T. post-temporal elevation.

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Fig. 1.

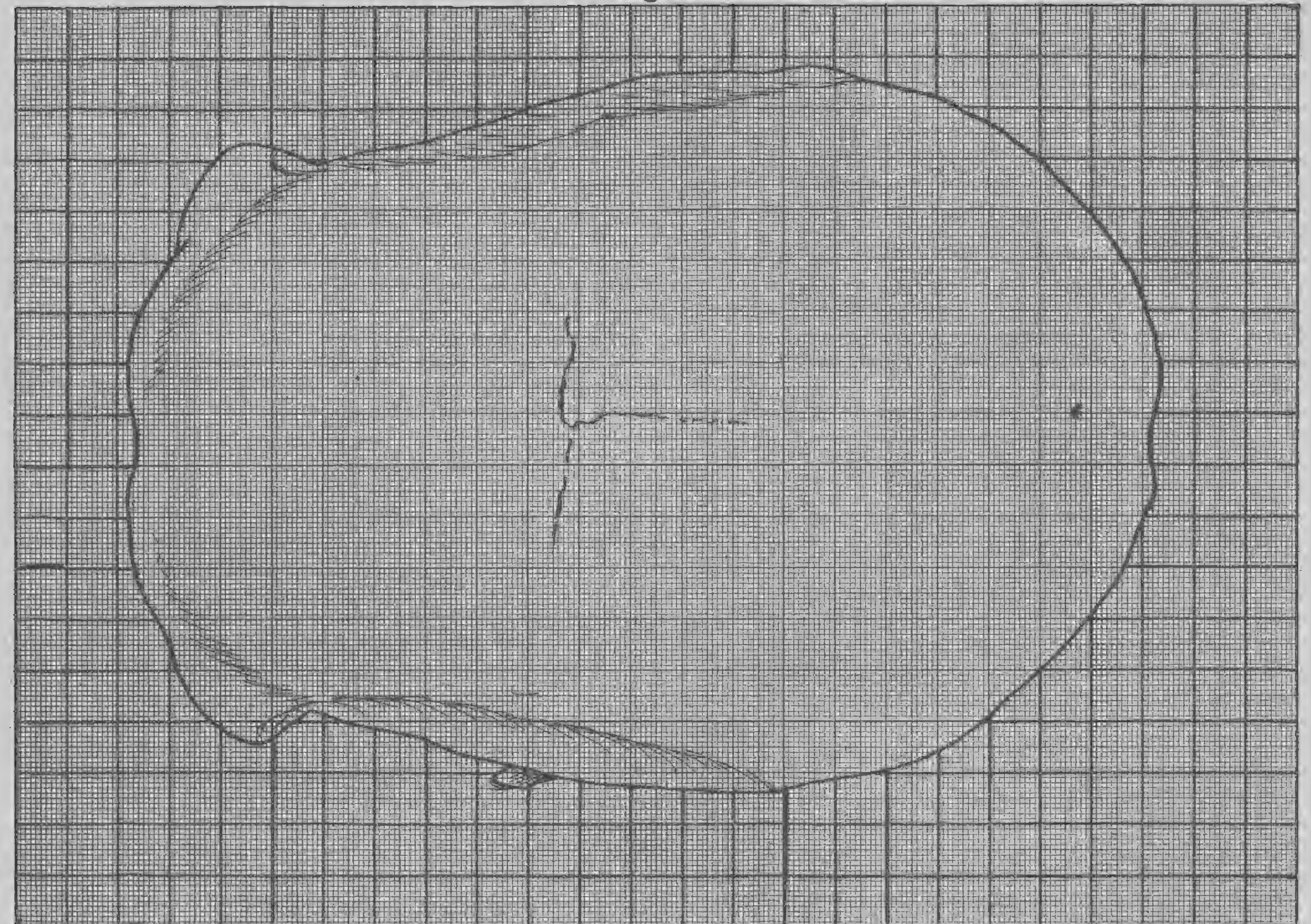

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Fig. 2.

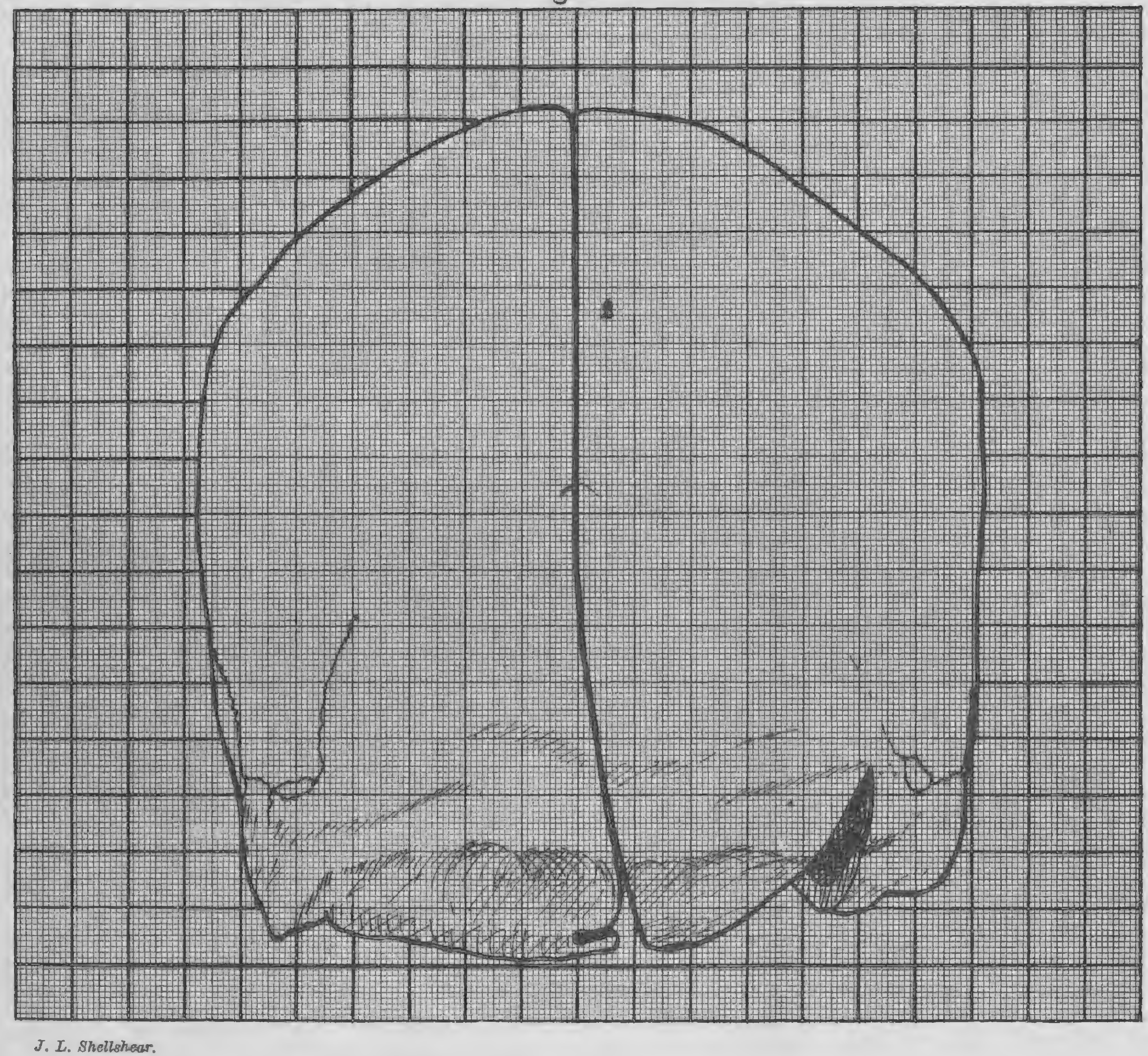

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Fig. 3.

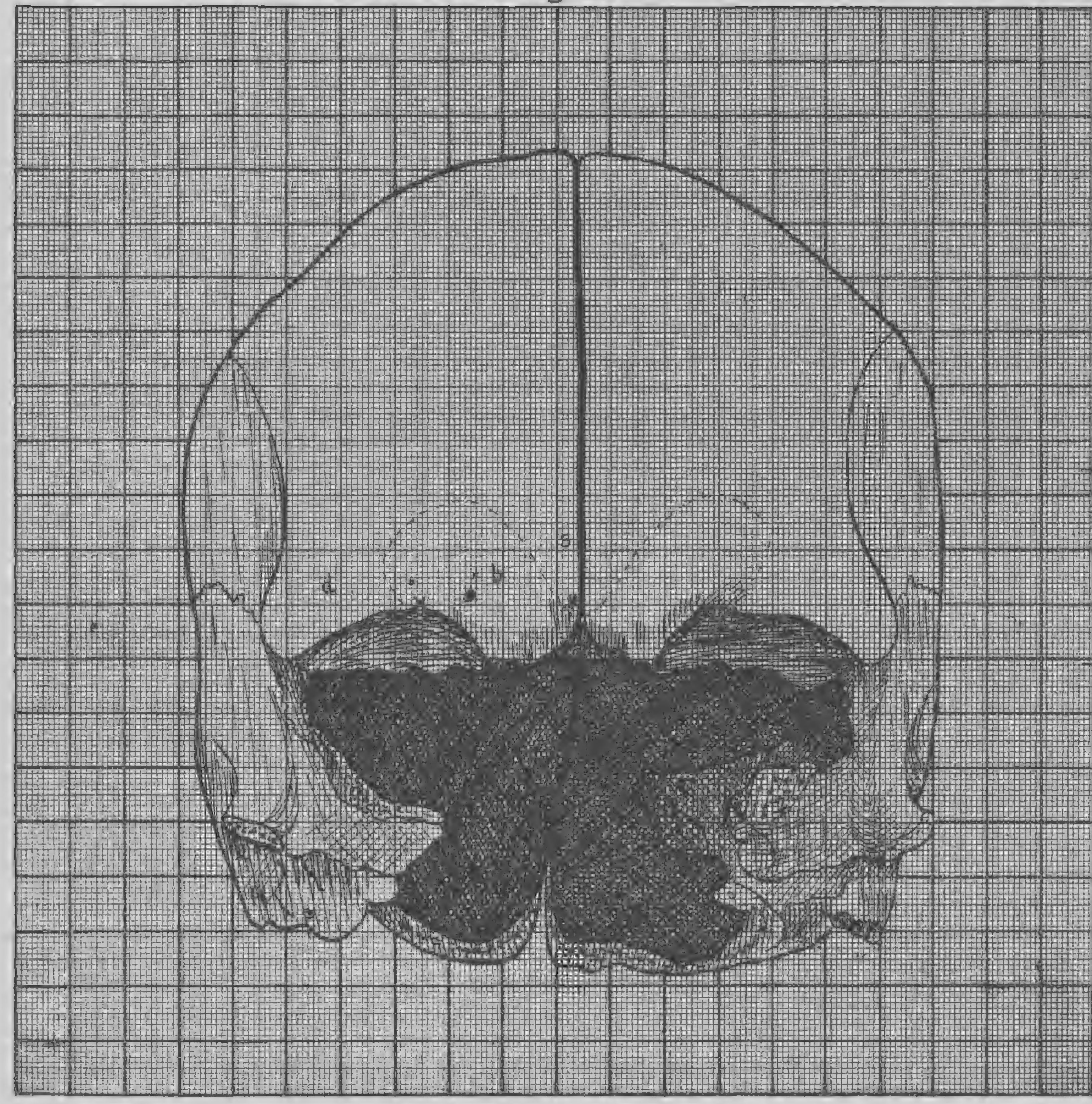

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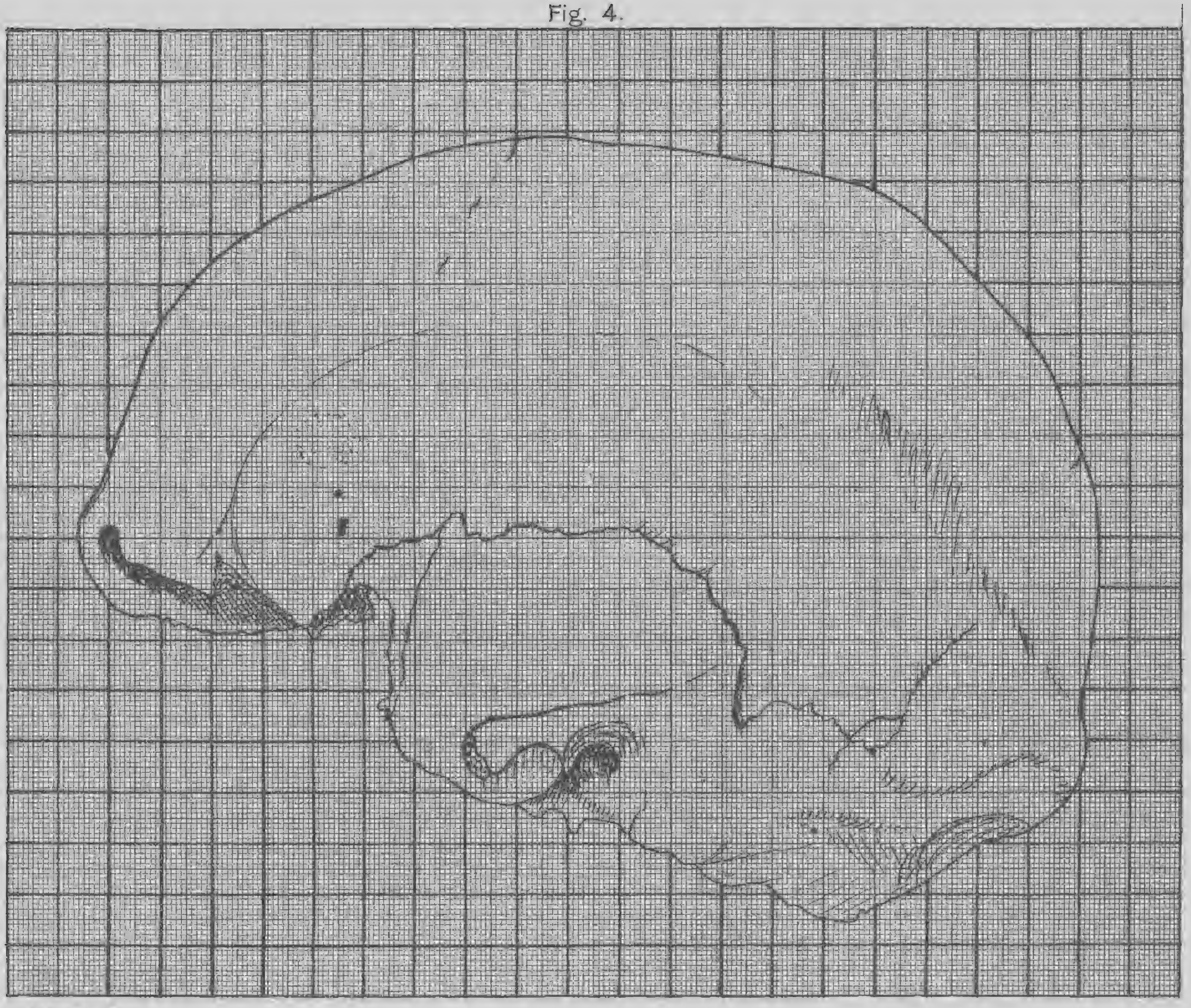
Fig. 4.



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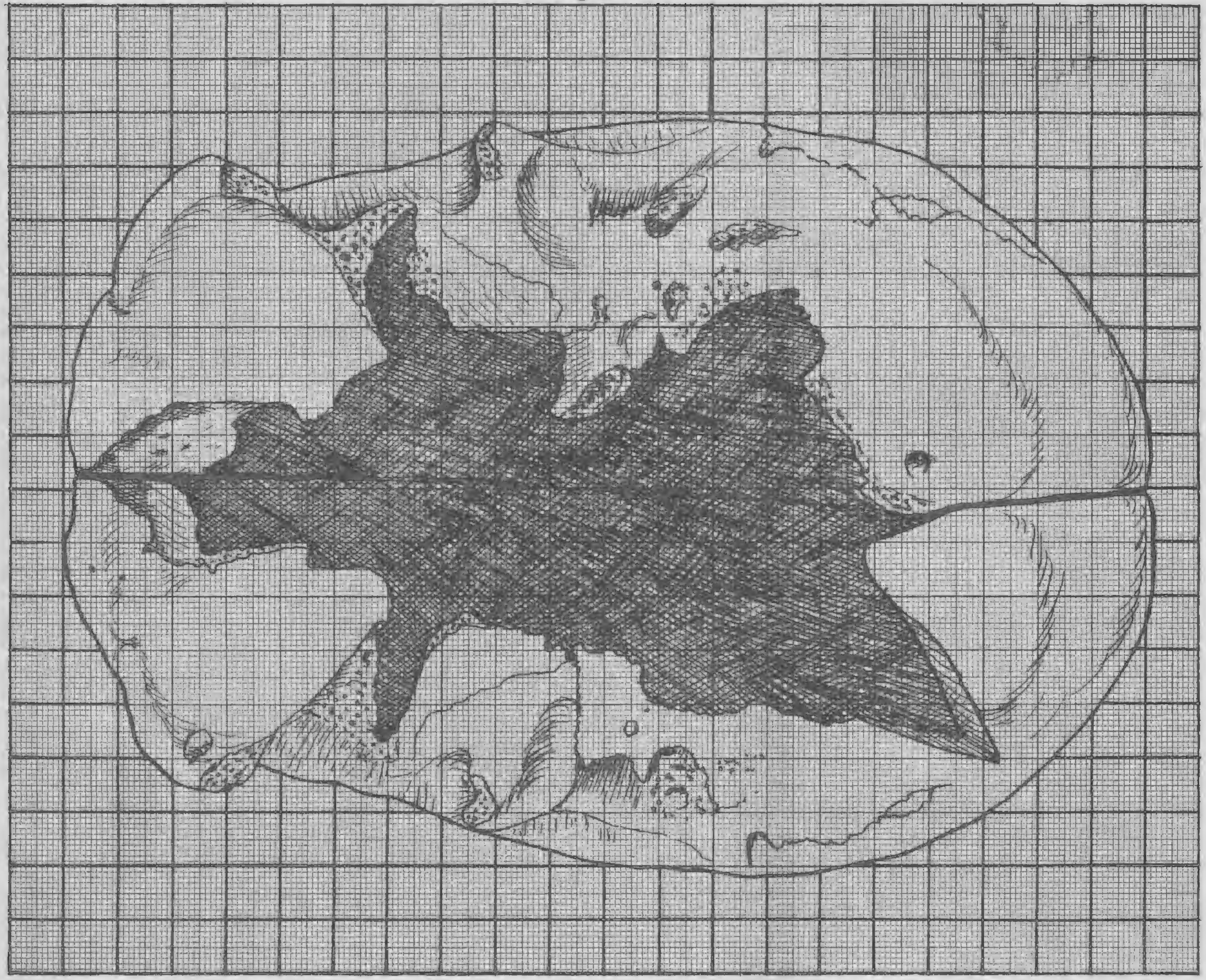

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Fig. 6.

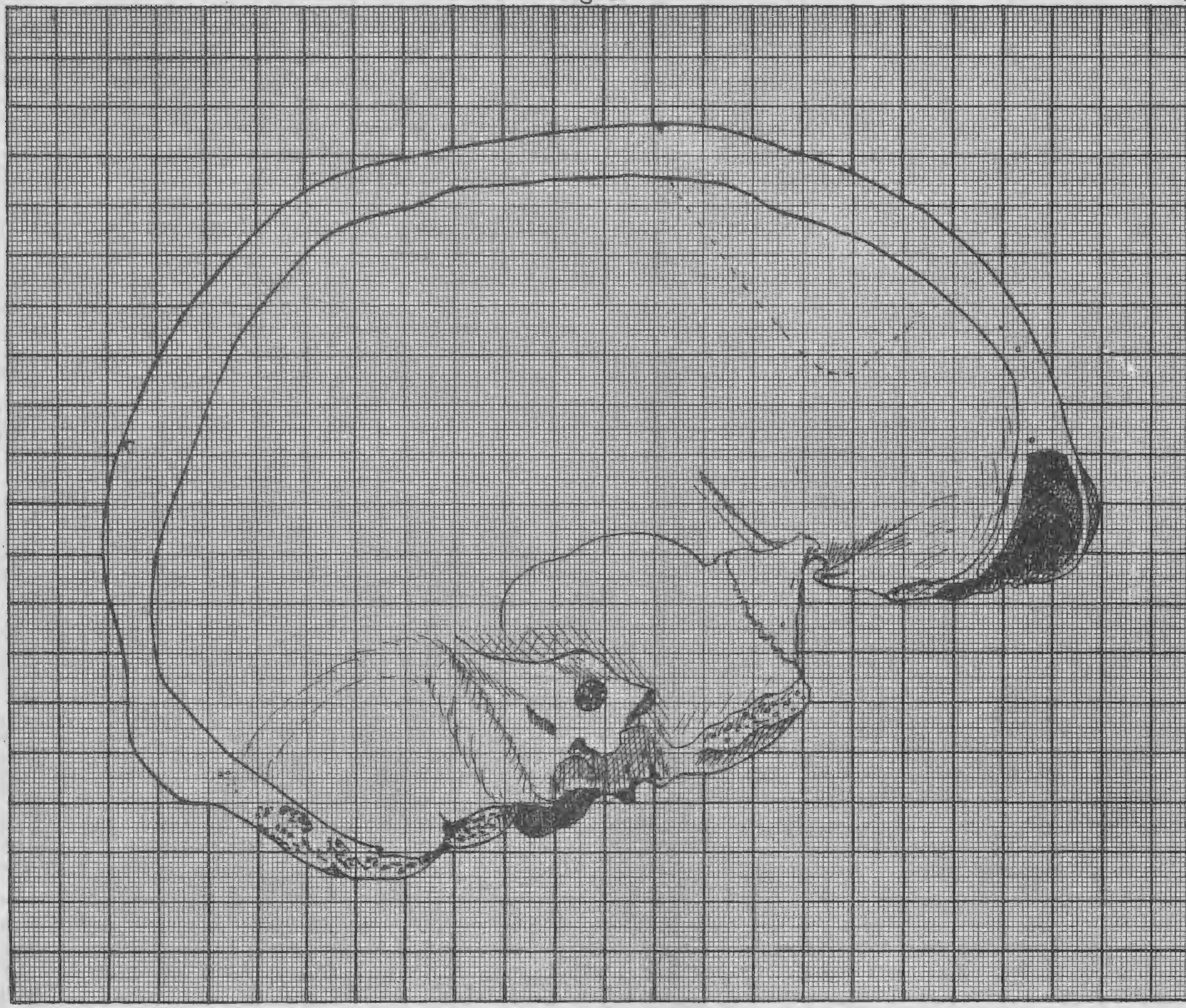

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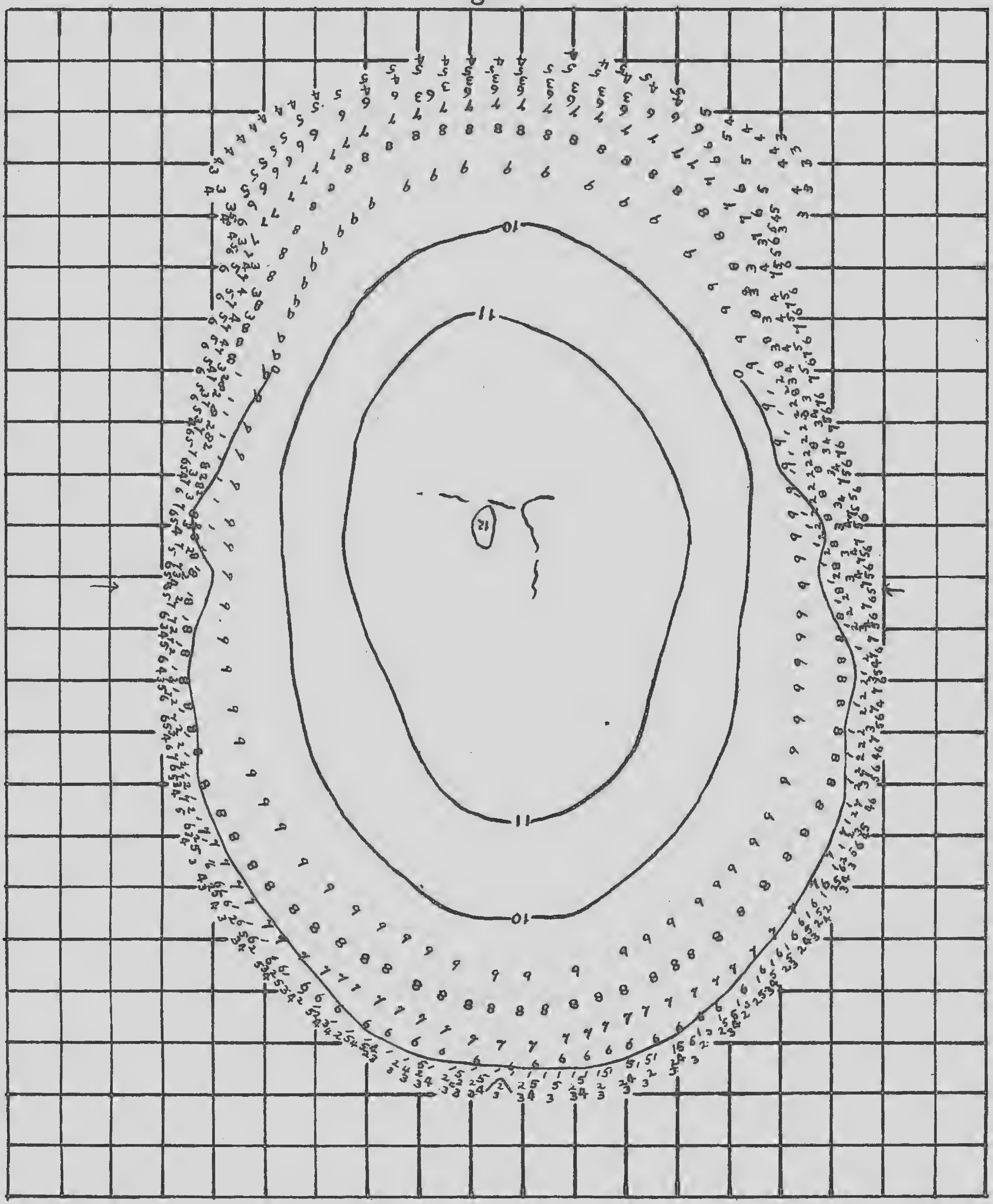
Fig. 7.



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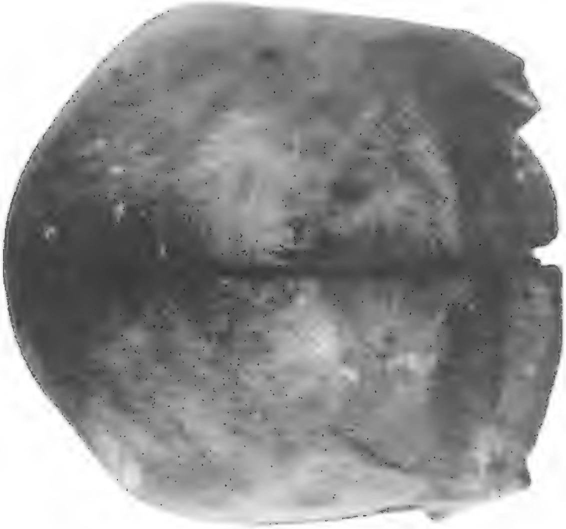

Fig. 9.

Fig. 11.

Fig. 8.

Fig. 10.

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Fig. 13.

Fig. 14.

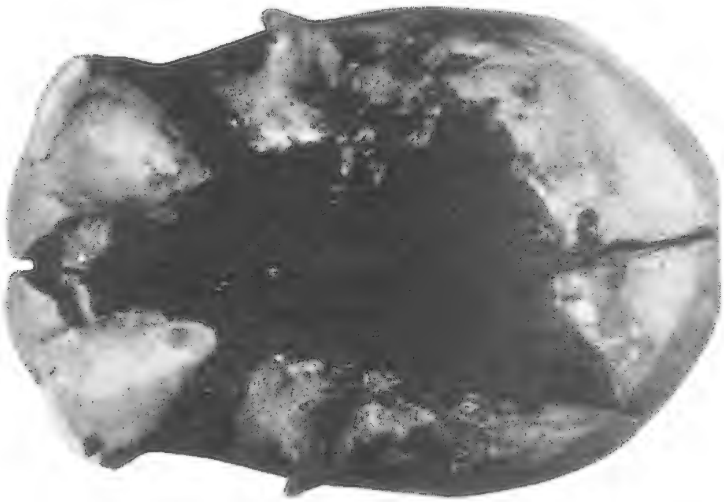

Fig. 12.

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Fig. 15.

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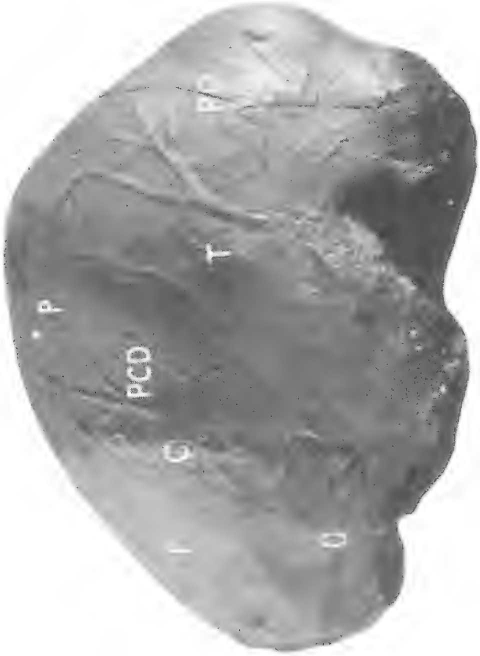
Fig. 17.



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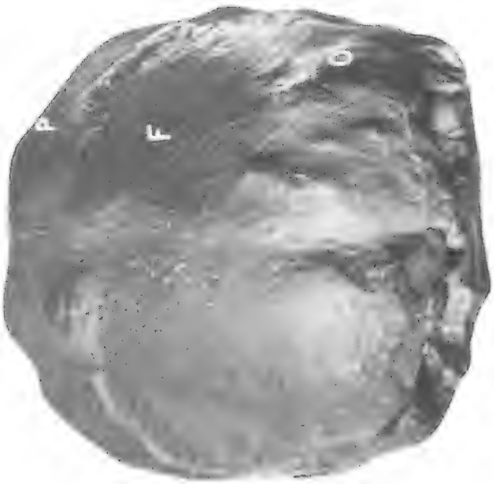

Fig. 16.

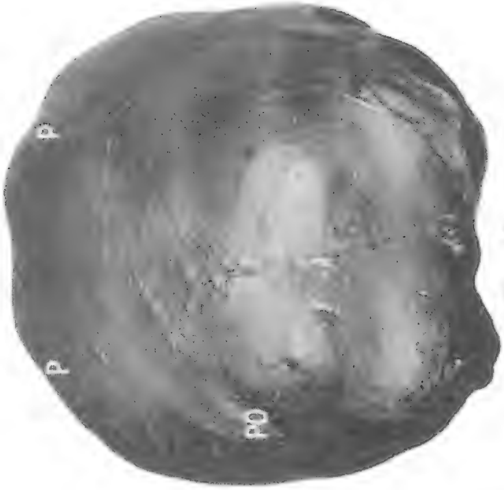

Fig. 18.

J. L. Shellshear.

THE CAMBRIAN FAUNAS OF NORTH-EASTERN AUSTRALIA.

PART 3: THE POLYMERID TRILOBITES.
(With Supplement No. 1.)

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(Plates XIX—XXV.)

1. ON CLASSIFICATION.

The trilobites appear suddenly, a highly organised, considerably differentiated order in the Cambrian, the earliest period in which fossils are adequately known. In Lower Cambrian beds they are represented by seven distinct groups—the agnostids, the codiscids, the mesonacids (with their relatives the Redlichiidae and Zacanthoididae), the conocoryphids, the ptychopariids and the group of large-tailed forms belonging to such related genera as *Bonnia* and *Kootenia*.

Slightly later in the Cambrian two other new groups appear, the Burlingiidae and the Menomoniidae, without any apparent links between them and the other groups. The normal, post-Cambrian, proparian trilobites—the Phacopidea of Richter (1932, p. 852)—may represent yet another distinct assemblage, making its first appearance early in the Ordovician. There may be other isolated groups; but it is possible that all known trilobite families may be traced back, more or less satisfactorily, to one or other of these early (Cambrian and Ordovician) units.

Some of the Lower Cambrian groups, the agnostids and the eodiscids particularly, are so different from the other stocks that their lineages clearly must have departed from the others at a much earlier period. But no earlier genera are known. We may have overlooked a number of Pre-Cambrian fossils ; but we cannot, surely, have failed to collect some of the earlier faunas if all the immediate predecessors of the Cambrian trilobites had hard parts.

These things strongly suggest that the ancestors of the trilobites, and even the earliest trilobites themselves, were soft-shelled or testless forms, a conclusion that may gain some support from the study of the segmental structures of *Redlichia*, described below.

Future collecting may close the gaps between some of these groups but it is hardly likely to bridge them all. Such evidence suggests to me that the trilobites already had diverged into a number of separate groups before the habit of strengthening the dorsum with lime developed ; that independantly, though not concurrently, calcification began in a number of lineages ; and that, probably, many lineages never developed a crusted test. Never, of course, did they evolve a hard, ventral integument. It is doubtful if any new calcified groups arose after the Ordovician ; but it is likely that soft forms persisted. As previously I have suggested (1936, p. 79) such strange creatures as *Marella* and *Mimetaster* may be end points of lineages, with but partly calcified dorsa, that arose from soft, near-trilobitic stocks.

If this be a correct explanation of the early history of the trilobites it will be rather difficult to construct a perfectly natural classification of the order, since many of the lineages are lost to us. The most adequate classification will be that which clearly expresses the relationships of the families of the trilobites to one another and to the several discrete units that independantly appeared.

Several workers have classified the trilobites by means of the variations of some single feature of the test. For such purposes Beecher (1897) used the type of facial suture, Gürich (1907) the number of thoracic segments, Poulsen (1927) the presence or absence of facial sutures. There is always a grave danger, in classifications based on unit characters, that homoeomorphs may be grouped together and cognate groups divided. Disregarding the polyphyletic Hypoparia, Beecher's grouping into Pro- and Opisthoparia seems to express a fundamental division even though there is an exception in the proparian *Jujuyaspis,* a member of the otherwise opisthoparian Olenidae. For such a grouping there is one debated section—the morphologically intermediate forms with sutures extending through the genal angle. These, including the families Menomoniidae, Triarthridae, Calymenidae and Homalonotidae, may be a natural, intermediate group (the Gonatoparia of Gürich) or the last three may

be offshoots from Olenidae which, considering the genus *Jujuyaspis*, would then be a rather insecurely opisthoparian group.

However in the classifications of the majority of recent systematists, for example Swinnerton (1915), Warburg (1925), Richter (1932) and Kobayashi (1935), there is a tendency to group the families into named genetic units and to pay less attention for the purpose of classification, to the variations of some single characteristic.

Such, it seems to me, is the logical method with the trilobites as now we know them ; and I suggest that the seven, discrete Lower Cambrian groups, with their descendant families, be treated as seven suborders as follows :

Mesonacida (Swinnerton), including Mesonacidae, Redlichiidae, Paradoxididae and probably Zacanthoididae.

Conocoryphida (Swinnerton), a small suborder restricted to the eyeless forms, recently reviewed by Resser (1936, pp. 13 et seq.).

Ptychopariida (Richter), a large suborder for Ptychopariidae, Anomocaridae, Olenidae etc.

Ellipsocephalida (nom. nov.), a small suborder for Ellipsocephalidae, Agraulidae, etc.

Corynexochida (Kobayashi), a large suborder, for families such as Corynexochidae, Asaphiscidae, Bathyuriscidae etc., leading to such groups as Asaphidae, Illaenidae, etc.

Agnostida (Kobayashi), for the many families recognised by recent division of the old Agnostidae (sensu lato).

Eodiscida (nom. nov.) for the blind eodiscids and the sutured forms such as *Pagetia*, *Delgadoia* and *Hebediscus*.

Little need be said about the Mesonacida, for this grouping has been used by many trilobite workers in recent years.

The Conocoryphida is a small group, similar to many of the ptychopariids in most features other than the presence of eyes and facial sutures[1]. It seems reasonable to suppose that they are the descendants of the blind stock from which Ptychopariida arose, shortly before the Cambrian. It is perhaps doubtful whether they should be treated as a separate suborder.

To Ptychopariida may be traced many families (Solenopleuridae, Olenidae, Anomocaridae, etc.) with many thoracic segments, small pygidia, and cephala that have prominent palpebral ridges and wrinkled pre-palpebral surfaces. Later they seem to have given rise to more specialised groups, notably the Harpidae.

[1] Whatever be the nature of the marginal suture in *Conocoryphe* it is hardly a true facial suture. I prefer Poulsen's suggestion (1927, p. 313) that it is a rostral suture. I find it difficult to accept Stubblefield's suggestion (1936, p. 419) that Conocoryphidae is a polyphyletic group of secondarily blind forms.

Ellipsocephalida usually have been included in Ptychopariida ; but in the Lower Cambrian they are sufficiently distinct to warrant separation. The simple form, the limited number of thoracic segments, the small pygidium and the large, smooth or little furrowed glabella, give them a characteristic appearance. In number of families Ellipsocephalida is probably not a large suborder ; but, if Proetidae rightly is to be placed therein it is an important group.

The opisthoparian trilobites with large pygidia are a very varied assemblage, even in the Cambrian. Many of the families appear to be descendants of such groups as *Bonnia* and *Kootenia* ; and for the time being I would unite the majority of such large-tailed forms (Corynexochidae, Dorypygidae, Dikelocephalidae, Asaphidae etc.) in this suborder. *Zacanthoides* and *Albertella*, from community of features, would seem to be offshoots from Mesonacida that early began to develop large pygidia. No doubt there are a number of offshoots from that and other suborders with increased pygidia ; but until such relationship is proved it may be convenient to group these morphologically similar forms.

With the proparian suborders and the development of post-Cambrian families, I am not in this paper concerned.

Three things particularly have concerned morphologists and systematists in their studies of the dorsal structures of the trilobites—the manner of fusion of the cephalic segments, the facial sutures (whether they are present or absent, and whether they are pro- or opisthoparian) and the number of post-cephalic segments (the relative number of the segments and the manner of their fusion into a pygidium). There are differences of interpretation of all these things ; but as a working hypothesis the following generalisations may be stated.

1. The fusion of the segments to form the cephalon took place, in Pre-Cambrian times, when the Trilobita was still a softly enveloped stock. The community of structure of the head of the diverse groups of trilobites indicates this.

2. The primitive groups of all natural sections of the trilobites were without facial sutures. From several such stocks the normally sutured trilobites developed.

The cephalic features of the new genus *Mesodema*, and the rostrum of *Xystridura saint-smithi* strengthen the belief that the families Redlichiidae and Paradoxididae arose from Mesonacidae that had no facial sutures. The eodiscids also seem to have produced several offshoots with eyes and facial sutures[2]. As

[2] Poulsen (1927) holds that the sutured *Pagetia*, so similar to the blind *Calodiscus*, is not related to it but is a homoeomorph ; but, as I have pointed out (1936, p. 81) the case for the derivation of sutured forms from blind eodiscids does not rest on *Pagetia* alone but on several genera (*Pagetia*, *Hebediscus* and *Delgadoia*), related to different sections of Eodiscida.

already noted some relatives of the blind Conocoryphida probably were ancestral to Ptychopariida.

3. The division into proparian and opisthoparian stock antedated the formation of facial sutures.

The function of the facial sutures, other than that it is in some way concerned with the visual organs, is problematical. They are the weakest sutures of the test as shown by the very common occurrence of trilobites complete except for the free cheeks. That they were necessary for ecdysis seems rather unlikely, since there was no hard ventral integument. The differentiation into pro- and opisthoparian groups early in the Cambrian and the apparent derivation of pro- and opisthoparian lineages from diverse sections of crusted, sutureless forms, suggests that the segregation into two such types occurred very early in the history of the order and so makes Beecher's systematic division, based on this feature, more satisfactory than any other unit classification.

4. In the earliest of the soft trilobites there was no fusion of the posterior segments to form a pygidium, which is a feature developed independantly by fusion in several groups.

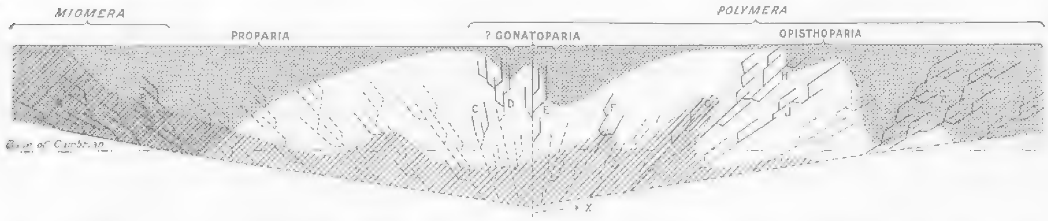
In so many lineages there is some increase in the size of the pygidium that such a generalisation seems warranted. The unfused posterior of the Mesonacidae is strong evidence in support. Swinnerton (1915) has postulated a general increase in trilobite stocks from micropygous to heteropygous to isopygous forms.

Using these generalisations to obtain a plan of the development of the order it would appear that fusion of posterior segments affected some lineages more than others before the advent of a crusted test. In Mesonacida there was no such previous fusion ; in Conocoryphida, Ptychopariida and Ellipsocephalida there was fusion to form a small pygidium ; in Corynexochida a large pygidium had been so formed ; while in Agnostida and Eodiscida the acme of pygidial formation had been reached before the test was calcified.

The formation of facial sutures was accelerated in some lineages, retarded in others. In Agnostida it was, apparently, always inhibited.

Diagrammatically, in text figure 1, I have sought to indicate, from such premises, some of these trends in trilobite morphology and to show how, in such a review of the evidence, they are related to developing lineages and the problem of primary classification.

Were all lineages, soft and crusted, known to us the agnostids and eodiscids would not be so far removed from the other groups ; but as it is they are so different that I regard Jaekel's division of the known trilobites into Miomera (the Agnostida and Eodiscida) and Polymera (the remaining groups) as most pertinent. Schuchert



Text-figure 1.—Some Suggested Trends in Trilobite Evolution. Unknown lineages of forms with uncalcified dorsa are suggested by broken lines. Lineages of hard-crusted forms are indicated, diagrammatically, by continuous lines. Within the lined area are only those forms that, primitively, have no facial sutures. Within the stippled area are only the isopygous and sub-isopygous groups. A Agnostida ; B Eodiscida ; C Burlingiida ; D Phacopida ; E ?Calymenida ; F Mesonacida ; G Conocoryphida ; H Ptychopariida ; J Ellipsocephalida ; K Corynexochida. X is the collateral branch leading to *Marella.*

(1936, p. 398) has criticised the division as " too simple to be acceptable " ; but Resser (1938b, p. 47) has even suggested removing the agnostids from the trilobites into a separate sub-class. Such a step I think unnecessary, Jaekel's grouping expressing well what seems to be a fundamental division.

2. SOME MORPHOLOGICAL FEATURES.

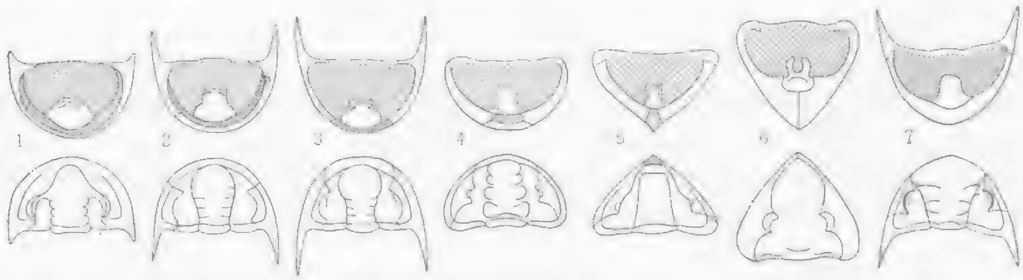
(*a*) Cephalic Sutures.

The type of rostrum now described for *Xystridura saint-smithi* (No. 2 in text figure 2) throws some light on the nature of the cephalic sutures. This rostrum extends completely around the inner edge of the cephalon, into the corners of the doublure beside the genal angles. That is, it is of the type previously known only in the Mesonacidae, and gives some additional support to the view that Paradoxididae arose from mesonacid stock. It throws light also on the vexed question of the homology of the cranidial sutures.

Barrande, in 1852,[3] suggested that the two branches of the facial suture, the rostral suture and the two ventral branches connecting these, together formed one unit, *la grande suture*, and that the hypostomal suture and the connective sutures were independant units. However, since in so many genera (Nos. 3, 4, 5 and 6 in text

[3] For a clear, diagrammatic and bibliographic presentation of these several theories see Stubblefield, 1936.

figure 2) the connective sutures link up in position with the facial suture and bound the rostrum, many later workers have held that the facial suture and the connective sutures are part of the same unit. Beecher believed that the rostrum was the axial part of an anterior segment of which the remainder of the doublure was the pleura. Kiaer has suggested that the rostrum originally was a segment anterior to the doublure and that it has been reduced in varying degrees in different genera as facial sutures have been modified. This idea has been developed further by Warburg, and the sections 1 and 3 to 7 in text figure 2, copied from Richter, show such a morphological suite of variants.



Text-figure 2.—Cephala of trilobites showing types of rostra and sutures (after Richter and Stubblefield). 1 *Kjerulfia*, 2 *Xystridura*, 3 *Paradoxides*, 4 *Calymene*, 5 *Homalonotus*, 6 *Isotelus*, 7 *Dalmanitina*. Rostra are shown by a stippled convention.

From a study of the rostrum of *Xystridura saint-smithi* the following conclusions may be drawn :

i. The rostrum in the sutured trilobites is of the same origin as that in the Mesonacidae.

ii. The rostrum is a segment anterior to the doublure and not the axial portion of it.

iii. The facial suture may be independent of the rostral suture, and *la grande suture* of Barrande is apparently a natural unit.

iv. Although in most genera the rostrum, where present, has a position within the doublure related to the type of facial suture,[4] such a correspondence is not without exception.

(*b*) Some Segmental Structures in *REDLICHIA*.

One remarkable specimen of *Redlichia idonea* has been found, an interior with imprints of what, at first sight, appear to be appendages. Photographs of an artificial internal mould, a plaster cast, are reproduced as figs. 5a, b of plate XIX.

[4] Even in the mesonacids, without ordinary facial sutures, there may be such an agreement ; for the lines that have been interpreted by some workers as anchylosed facial sutures, and by others as incipient sutures, sweep round, in their anterior branches, towards the genal angles.

Portion of the cephalon and nine thoracic segments are preserved on the specimen. Each thoracic segment has a structure that arises, at the intersegmental suture, from the ridge that divides the axis from the pleuron, and lies along the suture between adjacent pleura. These things are very irregular in thickness. Periodically they are thickened into sharp nodes, the internodal slope being gentle proximally and abrupt distally. The first of the nodes, in some segments, arises at the place of union of the structure with the test. In the posterior segments the nodes are very oblique, sloping backwards to the axis ; but on the anterior segments they become transverse or even slope the other way.

Comparing the proportions of the specimens illustrated by figures 5a and 2b of plate XIX it will be seen that the pleura are practically complete to their outer ends. Yet, while some of these thinner structures taper towards their distal ends, the majority do not decrease distally. Unless, when complete, some of them are abruptly trucated, then either they protruded beyond the ends of the segments or else, if internal, they were deflected within the doublure.

The maximum number of nodes (apart from a basal thickening) is eight, dividing the structure into nine sections. The minimum number is five.

The two comparable structures on the head are close together at the rear. The posterior member is similar in size to those of the thorax and three nodes are shown on it. The anterior member is thick, with two widely spaced nodes visible.

The following features need to be emphasised :

1. These structures are uniramous, occurring on both thorax and cephalon.

2. Although based on a common plan they vary in thickness and in the number of nodes.

3. Each structure is an entity—that is the structures of adjacent segments are not connected.

4. There is no indication that such structures were jointed appendages, formed of articulating segments. Each is an unsegmented unit periodically thickened into nodes.

5. There is no trace of an extension centrally beyond the point of attachment.

6. Each of these thoracic structures is a process not confined to one segment, but attached to the adjacent edges of two segments and lying along the sture between them.

7. There are no offshoots in the nature of gill blades or setae.

8. The fact that all thoracic structures are in the same corresponding position suggests that these processes were in contact with and probably attached to the inside of the test, so that they were internal. Thus they did not function as limbs. This conclusion is supported by the mode of attachment, so different from that of the known limbs of trilobites.

What, then, are these structures ? Apparently they are not limbs but some internal processes. They arise at the places where the flexor and extensor muscles most probably would be attached. They may be a curious type of muscle, extending along each pleural suture of the thorax ; but if so their presence on the posterior portion of the cephalic shield is somewhat difficult to explain. That many of them have nine internodes raises the question whether they are related to the endopodites that have seven segments (including the basipodite) ; but I find it difficult to believe that there was any type of correspondence, in linear detail, with a limb, which is external, and these features, that appear to be inside. If they were muscles they were strong muscles ; and since *Redlichia* is older than any known trilobite with limbs the question may be raised : did the primitive trilobites move by some means other than, or as well as jointed appendages—a legacy, possibly, from a crustless ancestor ?

It will be interesting to see if future collecting establishes similar structures in other trilobites or jointed limbs in *Redlichia*.

3. SYSTEMATIC DESCRIPTIONS.

Subclass TRILOBITA Walch, 1768.

Order POLYMERA Jaekel, 1909.

Suborder MESONACIDA Swinnerton, 1915.

Family REDLICHIIDAE Poulsen, 1927.

Genus **MESODEMA** gen. nov.[5]

Genotype : *Mesodema venulosa* sp. nov.

Diagnosis : Trilobites in which the cranidium agrees closely with that of *Redlichia*, except that the palpebral lobes arise directly from the frontal lobe of the glabella and the second glabellar lobe is continuous with the post-ocular portions of the fixed cheeks.

Remarks : The resemblance of *Mesodema* to *Redlichia* is particularly close. Were it not for certain structures, possibly vestigial, that are discussed below there would be no reason to separate the genotype from *Redlichia*. In general features of the cranidium it closely resembles *Redlichia nobilis* Walcott (1913, p. 105, pl. 7, figs. 12).

[5] μεσόδμη something built between.

Three other genera are included in the family—*Redlichia* Cossman 1902 (Genotype *Hoeferia noetlingi* Redlich),[6] *Neoredlichia* Saito 1936 (genotype *Redlichia nakamurai* Saito) and *Redlichaspis* Kobayashi 1936 (Genotype *Redlichia* (?) *finalis* Walcott). *Redlichia* is the first genus to appear, followed quickly by *Neoredlichia* and slightly later by *Redlichaspis*. Possibly in this order they represent a lineage.

Mesodema is closely allied to *Redlichia* (sensu stricto)—that is to the group of species with wide anterior limbs, including such forms as *R. noetlingi* (Redlich), *R. nobilis* Walcott and *R. chinensis* Walcott.

Since Walcott stated the proposition in 1910 (p. 53) it has been widely accepted that *Redlichia* is intermediate between the Mesonacidae (without facial sutures) and the Paradoxididae (typically opisthoparian). It is thus one of the most significant of trilobite genera. The thorax and pygidium are like many mesonacids. The head has normal facial sutures and, like all Opisthoparia with such sutures, the palpebral lobes are not confluent with the frontal lobe of the glabella. They do, however impinge upon it; and by so doing resemble the mesonacids more closely than any later forms.

Although *Redlichia* is transitional it does not adequately cover the gap between the two families. The new genus *Mesodema* is now another link in this chain, being intermediate between the mesonacids and *Redlichia*.

There are four features whereby the heads of mesonacids differ from those of all other trilobites. These are:

i. No facial sutures are present; but instead there are lines, usually raised but sometimes depressed, in positions where one would expect elements of the facial suture. These lines are almost invariably present in the post-ocular position; and in three genera at least (*Holmia, Kjerulfia* and *Callavia*) [7] they are known with pre-ocular branches as well. I propose the term "facial lines" for these structures.

ii. In the genera that have complete facial lines the anterior limb (i.e. the portion of the dorsal shield in front of the glabella and the anterior branch of the facial line) sweeps round towards the genal angles.[8]

iii. The palpebral lobes arise as pleural expansions of the frontal lobe of the glabella.

iv. In a number of genera (*Paedeumias, Olenellus* and *Holmia* for instance) the second lobe of the glabella is often laterally continuous with post-ocular portions of the cheeks.

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[6] Redlich (1899, p. 3, pl. 1, figs. 1-8) recognised two varieties and gave each a name (*angusta* and *lata*). One of these must be regarded as the type section and so lose its varietal name. Reed (1910, p. 7, pl. 1, fig. 14) subsequently figured a specimen of the narrow form as *Redlichia noetlingi*, this being the only other specimen that has been illustrated. Consequently I propose that the original of Redlich's plate 1, figure 1, be the lectotype and the name *angusta* accordingly, be abandoned.

[7] For figures see Kiaer, 1916, and Raw, 1936.

[8] Raw (1936, p. 239) has expressed this by using the term "metaparial" for facial structures that sweep round towards the genal angles.

Until recently a fifth difference could have been recorded—the rostrum of the mesonacids extends almost to the extreme posterior position, whereas in other genera the rostra are short. However later genera with rostra of maximum lengths are recorded in this paper.

Features ii, iii and iv are most strikingly expressed in the ontogeny of the species. For instance in the protaspis stages of *Holmia*, *Elliptocephala*, *Paedeumias* and *Olenellus*[9] the palpebral lobes are seen clearly to be the pleura of the frontal glabellar lobe while the post-ocular portions of the cheeks are just as evidently the pleura of the more posterior lobes of the glabella. The backwardly sweeping course of the anterior limb is well shown on these same figures.

The change from the mesonacid type to forms with facial sutures must have been particularly abrupt and revolutionary, one of the most complete and sudden changes in the known history of the trilobites. Not only are these four features suddenly removed from the heads of later adults but also they have been eliminated from the ontogeny of all later forms whose larval stages have been figured. The divorce is such that one might wonder whether the mesonacids left any descendants. Yet in *Mesodema*, with true opisthoparian sutures, there are vestiges of all these features.

The palpebral lobes in *Mesodema* arise from the frontal lobe of the glabella as perfectly as they do in the mesonacids. Similarly the second glabellar lobe grades no less definitely into the post-ocular portion of the cheeks. The greatly expanded anterior limb in *Mesodema* and the related species of *Redlichia* is morphologically intermediate between the sweeping mesonacid type and the much reduced form in other trilobites. This is particularly interesting in view of the reduction of the anterior limb in other lineages of *Redlichia*.[10]

Finally there are, on *Mesodema venulosa*, a pair of fine raised lines parallel and very close to the anterior branches of the facial sutures. On certain trilobites (ptychopariids and olenids particularly but also in some mesonacids), numerous, raised, radial lines occur on the anterior limb. Such structures have little more than ornamental significance and appear to be somewhat in the nature of wrinkles in the epidermis. The two definitely placed and widely spaced lines of *Mesodema* are not, I suggest, of this type. Rather, arising from the eyes, they appear to be vestiges of the facial lines. In passing it is worthy of note that in the mesonacids the anterior branches of the facial lines never extend across the marginal rim. The lines on *Mesodema* likewise stop at the rim.

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[9] For figures see Walcott, 1910, and Kiaer, 1916.

[10] Progressive reduction of the anterior limb is noticeable, to a slight degree, in the long-fronted Redlichias also (based on Saito's stratigraphical series).

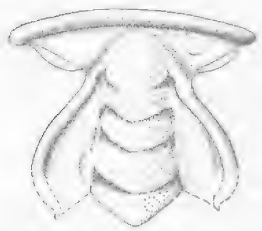
Mesodema is thus a trilobite on which, apparently, both facial sutures and facial lines occur. If, as seems generally to be conceded, facial lines are related to facial sutures, two interpretations of the mesonacid lines are possible. Either they are rudimentary and represent an incipient development, a forecast as it were of facial sutures, or they are vestigial and represent the lines of anchylosis of ancestrally free and fixed cheeks. Each interpretation has its adherents. Even if they are vestigial, separation of the cheeks might conceivably occur again along the course of the former sutures. The evidence now available suggests that, whatever be the origin of the facial lines, the separation of the cheeks to form facial sutures took place almost coincident with them.

MESODEMA VENULOSA sp. nov.

(Pl. XIX, fig. 1.)

Diagnosis: The cranidium is widest at the anterior margin, the width being slightly greater than the length. The glabella is long, narrow and subfastigate and it tapers uniformly but very gradually towards the anterior. On it four pairs of prominent but narrow furrows are impressed, each pair most deeply incised at the outer limits. Each pair of furrows is deflected posteriorly towards the axis of the glabella. The posterior pair, the occipital furrows, are continuous although they are but faintly impressed in the centre. The anterior pair are faintly impressed and short. The two intervening pairs of furrows are prominent and almost continuous. The occipital ring has no median spine but axially it is obtusely pointed. Anteriorly the centre portion of the glabella merges into the sinus behind the anterior rim.

The palpebral lobes are long and converge tangentially towards the front of the glabella. Together they limit a broadly pyriform area. These palpebral lobes arise, without intercepting furrows, from that portion of the frontal glabellar lobe immediately in advance of the anterior glabellar furrows. Their rims remain of constant length. Laterally beyond the anterior portions of the palpebral lobes furrows arise which, towards the front, bound the antero-lateral portions of the glabella.



Restoration.

Immediately behind the palpebral lobes a portion of the fixed cheeks arises on each side as a lateral expansion of the second glabellar lobe. That is, the axial furrows are here discontinuous. These furrows reappear to bound the third glabellar lobe but practically disappear again between the fourth lobe and the adjacent portions of the cheeks.

The anterior branches of the facial suture are widely deflected laterally, producing a wide anterior limb. On this, on either side of the glabella, there is a broadly convex fold radiating from the centre of the anterior margin. The anterior rim is long, wide, and almost straight. The facial sutures, in traversing the anterior rim and the fold behind it, have a " stepped " course.

On each side of the glabella a thin raised line arises near the anterior limit of the palpebral lobe and continues parallel to the facial suture, and about 1 mm. from it, as far as the posterior edge of the anterior rim. Here it tends to bend towards the axis and disappears.

Remarks : The significance of the several cephalic structures have been discussed in the remarks upon the genus. No other species of *Mesodema* is known and only the cranidium of the genotype has been found.

As previously indicated *Redlichia nobilis* Walcott is a very similar form among the Redlichias and the resemblance is close indeed. Among the mesonacids attention may be drawn to *Nevadia* and *Nevadella*[11] which alone of all those genera have conical, tapering glabellae. The resemblance in glabellar features to *Nevadella* is particularly striking. *Callavia* also is a genus whose glabella may be compared with that of *Mesodema*. Although not tapering it has similar types of glabellar furrows.

Locality and horizon : One specimen only, from the *Redlichia* Stage at Yelvertoft homestead. (University of Queensland Collection).

Genus **REDLICHIA** Cossman, 1902.

Genotype : *Hoeferia noetlingi* Redlich.[12]

REDLICHIA IDONEA sp. nov.

(Pl. XIX, figs. 2-11 ; pl. XX, figs. 1-5.)

Diagnosis : Test with a sublanceolate outline, tapering posteriorly.

Cranidium with a long, tapering, straight-sided glabella that reaches almost to the anterior rim. The occipital furrow and the two posterior glabellar furrows are continuous, and there is a third, faint glabellar furrow (anterior). These four furrows divide the glabella (and occipital ring) into four subequal parts. The axial furrow is

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[11] In erecting the genus *Nevadella* Raw (1936, pp. 243 and 249) did not specifically name a genotype. From his remarks it would appear that he regarded *Callavia eucharis* Walcott as the type species ; and I take that as genolectotype.

[12] See footnote 6 on page 188 of this paper.

continuous but it becomes shallow at the points where, in Mesodema, the two anterior lobes of the glabella are extended into the palpebral and post-palpebral structures. The axial furrow widens in the antero-lateral regions. The fixed cheeks are narrow, bounded by the long, slightly curving rim of the palpebral lobe. The anterior branch of the facial suture extends from near the axial furrow almost transversely to the margin. On the two lateral wings of the anterior limb there are, in some specimens, faint traces of the facial lines. The free cheeks are wide, little inflated with marked genal angles. The spines, which continue the curved line of the rim, are anterior to the genal angles.

There are fifteen segments in the thorax, the eleventh segment bearing a long, median spine. Posterior to this the segments become less prominent. The pleura, which have narrow, oblique grooves, terminate in short, backwardly directed spines.

The pygidium is very small, sub-globular, with a truncated posterior rim. The axis, which occupies most of its area, is bulbous, with three or four tiny axial rings. The pleura are short, merging into a posterior rim.

The rostrum is long, perhaps extending to the area of the genal angle. The hypostome is globular and is either fused to the rostrum or tightly attached across the suture.

The segments of the thorax and the posterior portion of the Cephalon bear uniramous structures, attached at the axial margin, and consisting of cylinders periodically thickened.[13]

Remarks : Over one hundred fragments of this species have been examined. Most of the cranidia are approximately 15 mm. long, but cranidia up to 60 mm. in length (pl. XX, fig. 1) have been obtained. Other structures occur proportionately. The total length of such a large specimen would be approximately 180 mm. (7 inches), by far the largest *Redlichia* yet discovered. There does not seem to be, in this matter of size, a division into two species or varieties, for adequate specimens of intermediate size also occur. The same features in size (an average, common size, with some specimens very much larger) has been noted also in the species *Xystridura saint-smithi*.

In the shallowing of the axial furrow near the first and second lobes of the glabella, and in the presence, occasionally, of traces of facial lines, a relationship is indicated with *Mesodema*.

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[13] These have been described in another section of this paper (pp. 185-187).

Redlichia idonea is most similar to *R. noetlingi* (Redlich) and *R. nobilis* Walcott (see 1913, p. 105, pl. 7, figs. 5); particularly to the Korean forms figured by Saito (1934, pl. XXVI, fig. 18) as *R. nobilis*. These species morphologically are intermediate between the long-fronted species such as *R. chinensis* Walcott (see 1913, p. 104, pl. 7, figs. 11), *R. manchuriensis* Endo and Resser (1937, p. 280, pl. 18, figs. 11-24), and *R. murakamii* Endo and Resser (1937, p. 281, pl. 19, figs. 7), and the forms with short anterior limbs, such as *R. coreanica* Saito (1934, p. 223, pl. XXVI, figs. 11-14) and *R. nakamurai* Saito (1934, p. 224, pl. XXVI, figs. 15-17). The outline tapers much more than in *R. mansuyi* Endo and Resser (1937, p. 282, pl. 19, figs. 1-3) and *R. yunnanensis* Endo and Resser (1937, p. 283, pl. 19, fig. 4). Two of the species from Yunnan are rather similar—*R. walcotti* Mansuy (1912, p. 26, pl. 3, figs. 4) and *R. carinata* Mansuy (1912, p. 27, pl. 3, figs. 5). However they are rather broader forms with slightly different facial sutures.

Redlichia has been recorded from Australia on several occasions. *Ptychoparia thielei* Chapman (1911, p. 316, pl. lviii, figs. 2, 3, 5, 7 and 10), from the Cambrian of Victoria, was placed in *Redlichia* by Walcott (1914, p. 62). *Ptychoparia minima* Chapman (1911, p. 318, pl. lviii, fig. 1) was referred doubtfully to the genus by Etheridge (1919, p. 389). Neither of these species is a true *Redlichia*. True species of *Redlichia* are represented by *Olenellus (?) forresti* (Etheridge fil. ms.) Foord (1890, p. 99, pl. iv, figs. 2a, b), which was placed in *Redlichia* by Walcott (1913, p. 104), the *Olenellus (?) sp.* figured by Etheridge from South Australia (1919, p. 382, pl. xxix, fig. 1), and the Kimberley specimens referred to by Chapman (1924).* Some of these latter forms were figured by Wade (1924, pl. 45). The heads are different from those of *R. idonea*, and suggest *R. forresti* (Foord); but the long tapering body is interesting, suggesting some relationship with the present form. Through the courtesy of the British Museum (Natural History) I have had the opportunity of studying a plaster cast of the holotype of *R. forresti*. It is not well preserved, but differs from *R. idonea* in being more inflated and with less well defined glabellar furrows. The South Australian specimen already referred to was loaned to me by Sir Douglas Mawson from the University of Adelaide Collection. It is a flatter form with faint furrows, quite distinct from *R. idonea*.

Localities and horizon: All figured specimens and many others are from the *Redlichia* Stage at Yelvertoft Homestead. (University of Queensland Collection and also Schmidt Collection, on loan to the University of Queensland.) A few specimens have been obtained also from beds at the base of a hill, about 16 miles from Yelvertoft dip on the road to the Paradice Goldfield.

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* Since the above was written I have examined Chapman's types. All of his Cambrian trilobites from the Kimberley district appear to be species of *Redlichia*.

Family PARADOXIDIDAE Emmrich, 1839.[14]

Subfamily PARADOXIDINAE Howell, 1933.[14]

Genus **PARADOXIDES** Brongniart, 1822.

Genotype : *Paradoxides tessini* Brongniart.

PARADOXIDES PEREGRINUS sp. nov.

(Pl. XX, fig. 6.)

Diagnosis : Cephalon and anterior thoracic segments unknown.

The posterior portion of the thorax (excluding the spines) has a semicircular outline. The axis is wide, tapering rather quickly in the last three segments. Pleura are obliquely grooved, each groove slowly widening and deepening until the base of the spine is reached when it terminates rather suddenly. Where the doublure begins the pleura are prolonged, without contracting in width, as long, backwardly sloping spines, each with a channelled centre. The outline of a complete pleuron is subfalcate, with the fulcrum situated just before the doublure begins.

The pygidium consists of a tail plate and one fused anterior segment. This tail plate is long, with parallel sides at right angles to the anterior furrow, and terminates in two long, thick spines contiguous where they leave the margin. This tail plate shows no differentiation into axial and pleural portions. The fused segment is similar in all respects to the adjacent thoracic segments, but the pleura are reflexed immediately they leave the axis.

Remarks : Trilobites with long, pleural spines and with the pygidium composed of little if anything more than a tiny tail plate are characteristic of the three early groups of the Mesonacidae, Redlichiidae and Paradoxididae, the families that Richter (1932, p. 855) united as the superfamily Redlichiidea. The type of tail plate, without transverse furrows or defined pleural zones, is most similar to that of certain mesonacid genera (*Wanneria* for instance) to which it shows other resemblances in the type of posterior spines. But the presence of a fused anterior segment is something foreign to the mesonacids and allies the species to the other groups. Clearly on general features it is not a *Redlichia* ; and since in certain forms of *Paradoxides*, for example *P. davidis* Salter, all its essential features are repeated, I have little hesitation in referring this new species to *Paradoxides*. The bed from which it is recorded (on the Templeton River)[15] is well within the Middle Cambrian and so later than all known deposits with Mesonacidae.

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[14] In conformity with the decisions of the International Zoological Congress I have used the spellings Paradoxididae and Paradoxidinae instead of the forms, Paradoxidae and Paradoxinae, adopted by the authors who first named these divisions.

[15] I may say that the specimen is preserved in a fragment of smooth, buff-coloured chert of a type that is common at many horizons in the Queensland Cambrian sequence. Cherts of this type occur in the beds on the Templeton River but are not very common there in the fossiliferous portion. I have wondered, sometimes, whether this specimen is rightly recorded for its locality. The late Mr. Dunstan who collected the specimen for the Geological Survey cabinets, collected also at Yelvertoft Station where such cherts (in both *Redlichia* and *Dinesus* Stages) are very common. There may be a confusion in localities, although I would not like to affirm this.

Only one specimen is known, a posterior fragment 10 mm. long, on which the anterior pleura are telescoped over some of the later segments. Nevertheless in its features it is sufficiently distinct from all other described species so that I have thought it worthy of a name.

Species of *Paradoxides* with long, delicate, pleural spines are known from many horizons, from the earliest hemerae in the range of the genus to near its close. Well known species of this type include *P. oelandicus* Sjögren, *P. pinus* (Holm ms.) Westergaard, *P. bidentatus* Westergaard, *P. tessini* Brongniart, *P. bohemicus* (Boeck), *P. spinosus* (Boeck), *P. barrandei* Barrande and *P. davidis* Salter. However in the features of the pygidium *P. peregrinus* differs from all such forms although it is most similar to *P. davidis*. It has a spinose segment, generally similar to the thoracic segments, fused anteriorly to the tail plate. So far as I am aware, *P. davidis* Salter (see Lake, 1935, p. 203, pls. 27 and 28) is the only other spinose *Paradoxides* that has this feature. The pygidial spines of *P. peregrinus* are stouter and longer than in any other species of the genus. There are many species of *Paradoxides* with simple, non-spinose margins to the pygidium. Other forms have spines, some a pair of marginal spines, others two pairs.[16] But the spines are never massive and between them there is generally a portion of the normally curved margin. In this species the spines diverge in a V-shaped manner without the intervening curves. The outer edges of the spines continue the straight, lateral lines of the tail plate. Yet another pecular feature is the uniform surface of the tail plate. These plates vary considerably in this genus. In some forms, for instance *P. bohemicus* (Boeck),[17] there is clear evidence on the axis that the plate is composed of fused segments. In others evidence of segmentation is suppressed and the axis is smooth, without transverse furrows. But even in these there is differentiation between the axial and pleural regions. In *P. peregrinus* elision of the surface detail is further developed and the surface of the tail plate is not so divided. One of the specimens of *P. davidis* Salter figured by Lake (1935, pl. 28, fig. 3) has a tail plate in which there seems to be a similar lack of division between axis and pleura.

The variation within the genus *Paradoxides*, as it is understood at present, is such that, as Howell (1933, p. 216) has suggested, it may be expedient before long to make some subdivision. But the group is a unit, whether it be interpreted as a genus or a subfamily, and as such was known hitherto only in the atlantic province of western Europe, northern Africa and eastern North America. To record a species

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[16] In some curious variations of *P. bidentatus* Westergaard (1936, pl. 3, figs. 10 and 11) figured specimens with three and possibly four pairs of pygidial spines.

[17] See Barrande (1852) pl. 10, fig. 22.

as far distant from the province as Australia is of more than ordinary interest. *Paradoxides* must have been a rare form in these southern waters ; for only the one specimen has been obtained from beds in which other trilobites abound.

Locality and Collection : Holotype (in the collection of the Geological Survey of Queensland) from the *Dinesus* Stage of the Templeton River (probably from Beetle Creek).[18]

Subfamily XYSTRIDURINAE nov.

Taken generally we may recognise three main morphological, probably genetic, groupings of the genera that usually are placed in Paradoxididae. The type section to which Howell in 1933 gave the name Paradoxinae (here transcribed as Paradoxidinae)[19] included *Paradoxides* Emmrich and *Plutonides* Hicks. No doubt, as Howell (1933, p. 215) has suggested, it may be expedient before long to divide *Paradoxides* into a number of genera,[20] all to be grouped in Paradoxidinae. The second division, including the genera *Centropleura* Angelin, *Anopolenus* Salter and *Clarella* Howell, comprises the subfamily Centropleurinae.[21] *Metadoxides* Bornemann, *Catadoxides* Matthew and *Anadoxides* Matthew form a third group for which I suggest the new subfamily name of *Metadoxidinae*. It is possible that the family begins in the late Lower Cambrian, with the incompletely known genus *Strettonia* Cobbold (1931, p. 471).

Paradoxidinae have expanding glabellae, palpebral lobes that are not in contact with the glabella, and tiny pygidia usually with unbroken margins but occasionally with four spines. Centropleurinae differ in having the anterior section of the facial suture extended considerably at either end, a pair of anterior glabellar furrows that converge posteriorly, and a relatively large pygidium on which the four spines are permanent, thorn-like structures. Metadoxidinae differ from the other groups in the narrowing glabella.

Xystridura, as Kobayashi (1935, p. 126) has noted, has characteristic paradoxidid features. But it is difficult to place it in any of these three groups. Clearly, with its expanded glabella, it has no close relationships with Metadoxidinae. It has a cephalon precisely of the same type as Paradoxidinae but a pygidium of the same form as Centropleurinae. From the stratigraphical position of the Templeton Series,

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[18] See footnote on page 194.

[19] Kobayashi (1935, p. 127) independently has made the same suggestion.

[20] If *Paradoxides* is to be subdivided then Hicks' name *Plutonides* no doubt will be retained for one section. For that reason I have listed the name in this paragraph.

[21] Howell, in 1933, proposed Centropleurinae as a new subfamily. But in 1854 Angelin had used the name Centropleuridae ; so that it is preferable, as I see Kobayashi (1935, p. 127) recently has done, to credit Angelin with the name when using Centropleurinae as a subfamily.

where it occurs, *Xystridura* must belong to the early part of the range of Paradoxididae. Centropleurinae, as at present we know the group, occur only late in this range. It may be, therefore, that *Xystridura* is an early form of Centropleurinae, developed from Paradoxidinae, in which the pygidium has assumed the new features but not the cephalon. I do not think so. The pygidial features are even more strongly developed than in the three genera of Centropleurinae, whereas the cephalon is more remote from the centropleurid type than is the average species of *Paradoxides*. For instance there are no reflexed glabella furrows and the facial suture shows not the slightest tendency to the incised pre-palpebral form of Centropleurinae. Actually the facial suture is further removed from the glabella than in the majority of species of *Paradoxides*. From these premises it seems to me improbable that *Xystridura* is on the lineage leading from Paradoxidinae to Centropleurinae but rather that it is a separate offshoot with a *Paradoxides*-like head, and a relatively large, quadrispinose pygidium.[22] I therefore have placed it in a separate subfamily.

Genus **XYSTRIDURA** Whitehouse, 1936.[23]

(= *Milesia* Chapman 1929, non Latreille 1804)

Genotype : *Olenellus Brownii* Etheridge fil.

Diagnosis : Dorsal shield regularly ovate, little inflated.

The cephalon is large and semi-circular. The glabella expands anteriorly, reaches to the anterior furrow, and is marked by an occipital furrow and three other discontinuous glabellar furrows. The fixed cheeks are wide, flat, and generally give a sub-quadrate outline to the cranidium. The palpebral lobes are regularly arcuate, not in contact with the glabella and with a marked impression (?muscle scar) at each posterior extremity. Facial sutures have divergent anterior branches and very short posterior branches. The anterior branch of the facial suture meets the palpebral lobe at some considerable distance from the glabella. Free cheeks have moderately long genal spines.

The thorax consists of thirteen segments. The axis is about one fourth the total width and is not indented. The pleura end in obtuse, reflexed spines, the fulcrum being near the inner end of the doublure. Each pleuron is obliquely grooved and, adjacent to the axis, has a prominent impression (muscle scar).

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[22] If the late Lower Cambrian genus *Strettonia* is indeed a member of Paradoxididae it, rather than *Xystridura*, might have claims to be an early form of Centropleurinae. In that genus both cephalon and pygidium have such incipient centropleurid tendencies. This raises the question of whether Paradoxidinae or Centropleurinae is really the parent stem or whether, perhaps, a *Strettonia*-like lineage may have persisted and given rise to all subfamily groups.

[23] As a nomen nudum the name *Xystridura* dates from 1932 when David (1932, p. 37), in using some of my manuscript notes, quoted it in a list of genera of the Templeton Series.

The pygidium is about one sixth the length of the test. Its axis has two anterior furrows and a relatively large, unfurrowed extremity. The pleural portions of the pygidium are wide, with four widening furrows on each side and with a flat margin ending in four wide, short and recurved spines.

The rostrum is a narrow semi-circular band agreeing in shape with the anterior border of the cephalon but completely separated from it by a suture.

The hypostome is semicircular in the anterior portion. It narrows posteriorly, ending in a straight margin. The hypostome is not permanently attached to the rostrum.

Remarks: The forms from the Templeton River that here are recorded as *Xystridura* were placed by Chapman (1929) in the established genera *Bathyuriscus, Marjumia* and *Dikelocephalus* and a new genus (of preoccupied name), *Milesia*. Recently Kobayashi (1935, p. 126) noted the resemblance to Paradoxididae and in doing so drew attention to the extreme improbability of the forms having any relationships to the three established genera that were quoted. The agreement with Paradoxididae is strong. As mentioned above the head is precisely of the type seen in many species of *Paradoxides*; the thorax has the normal features of the family; and the pygidium is of the same type as that of the subfamily Centropleurinae.

XYSTRIDURA BROWNI (Etheridge fil.)

(Pl. XXI, fig. 1.)

1897 *Olenellus Brownii* Etheridge Jr., p. 13, pl. 1, fig. 1.
1919 *Olenellus (?) browni* Etheridge Jr., p. 381.
1936 *Xystridura browni* Whitehouse, p. 74.

Etheridge originally described the species in the following words:

Sp. Char.—General form unknown. Cephalon, or cephalic shield, subsemicircular; width all but double the length; frontal and lateral borders thickened and raised; posterior border to all intents and purposes straight. Glabella rather pyriform, in front abutting against the frontal border; axial grooves well marked and deep; basal furrow continuous across the glabella, and very faintly V-shaped; the second and third furrows horizontal, leaving between their inner ends a slight median longitudinal convexity; frontal lobe subsemicircular and largest, the second lobe next largest, the third next, and the basal lobe smallest, the two halves of the latter somewhat wedge-shaped. Neck segment narrowly oblong, with a central tubercle; neck furrow deep and horizontal. Eye lobes narrow, semilunate, extending from opposite the foremost pair of glabella furrows to the posterior margin; palpebral lobes appear to be deltoid; genal spines short extending to the third and perhaps the fourth pleura. Two anterior thoracic segments of equal width, slightly convex, of equal width with the pleurae, or if anything very slightly wider, devoid of median spines or nodes; two anterior pleurae flat, slightly inclined from the axis, the geniculation apparently feeble, the anterior margins strong and very marked. Sculpture anastomosing lines faintly visible on the cheeks.

Only the one specimen, the holotype, is known. On the left side of this specimen the facial suture is clearly shown, the anterior branch making an acute angle with the palpebral lobe and a right angle with the lateral margin. The posterior limb is very short, because of position of the eye. Etheridge was doubtful whether this was a true facial suture or a crack, and so placed the species in *Olenellus*. It is, however, a regular suture of the type met with in the Paradoxididae.

I have not been able to see, on the specimen, the " anastomosing lines faintly visible on the cheeks " ; but the specimen is preserved in an earthy limestone, with a friable surface, so that it is possible that fine detail which was visible in 1897 has since disappeared.

Apart from these features Etheridge's description gives an adequate account of the holotype. Two notable characters are the length of the cephalon and the shortness of the thoracic pleura.

Locality and horizon : From beds of the *Dinesus* Stage in " a well, 200 feet deep, five miles north of the station [Alexandria]." (Eth. fil.) The holotype is in the Australian Museum Collection.

XYSTRIDURA SAINT-SMITHI (Chapman).

(Pl. XXI, figs. 2-16 ; pl. XXII, figs. 1, 2.)

1929 *Bathyuriscus saint-smithii* Chapman, p. 209, pl. XXI, figs. 7, 8.
1929 *Bathyuriscus nitidus* Chapman, p. 210, pl. XXI, fig. 9.
1929 *Bathyuriscus olenelloides* Chapman, p. 210, pl. XXI, fig. 10.
1929 *Marjumia milesi* Chapman, p. 211, pl. XXI, fig. 11.
1929 *Marjumia conspicabilis* Chapman, p. 212, pl. XXII, fig. 13.
1929 *Marjumia elegans* Chapman, p. 212, pl. XXII, figs. 14-16.
1929 *Dikelocephalus dunstani* Chapman, p. 213, pl. XXII, figs. 17, 18.
1929 *Milesia templetonensis* Chapman, p. 214, pl. XXII, fig. 19.
1931 Unnamed trilobite, Anderson, text. fig.
1935 Unnamed trilobite, Fletcher, text. fig.
1936 *Xystridura saint-smithi* Whitehouse, p. 62.
[*non* 1936 *Xystridura sp. indet.* Tillyard, pl. D].

Remarks : This trilobite occurs in colossal numbers in the shales of Beetle Creek, 14 miles north-west of Mt. Isa and in other less known localities. From these beds I have examined a large number of complete specimens and many fragments. Also I have had the opportunity of studying the specimens described by Chapman in 1929. As a result I have no hestitation in grouping as the one species the forms, listed above in the synonymy, which he placed in four genera and eight species. The holotypes of Chapman's species are refigured on plate XXI. A number of his specimens were fragments. One was a very immature specimen and another was badly worn. But when they are compared with a suite of complete and undistorted specimens the specific identity of these eight forms is apparent. Some of Chapman's

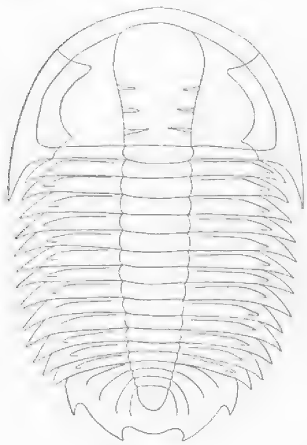
statements are in need of correction. For instance, six of his holotypes have a complete thorax, each with thirteen segments (the normal number); but the number of thoracic segments that he quotes for these is as follows: *Bathyuriscus saint-smithi* (12), *B. olenelloides* (10), *Marjumia milesi* (not stated), *M. conspicabilis* (14), *M. elegans* (14) and *Milesia templetonensis* (12).

The first species described by Chapman was *Bathyuriscus saint-smithii*; and accordingly I regard the other seven names as synonymous with this. In conformity with the international rules I have used the spelling *saint-smithi*.

The specimens that I have examined range in length from 3 mm. to 180 mm. Specimens from 60 to 100 mm. long are the most common.

The species may be re-described as follows:

Outline regularly oval. The cephalon is subsemicircular. The glabella widens anteriorly, after a slight constriction at the posterior third, and anteriorly impinges upon the rim. The occipital furrow is continuous, although faintly impressed at the centre. There are three pairs of glabellar furrows proper, each pair narrow and discontinuous; the posterior pair are directed posteriorly, the others are strictly transverse. Fixed cheeks are flat. The palpebral lobes are long, with muscle scars at the posterior ends. They reach posteriorly almost to the border. The anterior branch of the facial suture makes an acute angle with the palpebral lobe and is subtransverse. Free cheeks bear prominent genal spines. The rostrum is semicircular, extending to the posterior angles of the doublure of the cephalon. The hypostome is very wide anteriorly, with a short, narrow, posterior extension that has subparallel sides. The anterior lobe extends to the anterior and lateral margins. Maculae are transversely elongate. The posterior lobe is practically non-existant. Anterior and posterior wings are small.



Restoration.

The thorax consists of thirteen segments. The axis is about one-quarter the total width and simply arched. The pleura are relatively flat, with prominent, oblique furrows and short, wide spines. The doublure is relatively wide.

The pygidium has a short axis transversely divided by three furrows into three narrow rings and a sub-globose posterior lobe. Four arcuate pleural grooves occur on each side, terminating in shallow pits a short distance from the margin. There are four, prominent, equally spaced, marginal spines, thorn-like in appearance.

From *X. browni* (Eth. fil.) the species is distinguished by a shorter cephalon and longer thoracic pleura.

A feature of considerable interest is the length of the rostrum, which extends into the postero-lateral angles of the doublure. That is, it is not limited by the facial suture. Several isolated rostra have been collected, while many specimens

of complete individuals are internal moulds showing the rostrum in place, or slightly displaced, often with the hypostome in position. For instance, on the holotype (pl. XXI, fig. 2) the rostrum can be seen slightly displaced. On the specimen shown in pl. XXII, fig. 1, the rostrum and the hypostome are *in situ*.

The smallest specimens (pl. XXI, fig. 16) have very long, needle-like, genal spines and long meta-cranidial spines. From that stage onward the length of the genal spines gradually decreases. The small specimen chosen by Chapman as the holotype of " *Bathyuriscus nitidus* " (pl. XXI, fig. 4) shows the long genal spines of an immature individual.

Localities and horizon : From beds of the *Dinesus* Stage. The holotype, in the collection of the Commonwealth Geological Survey at Canberra, was recorded by Chapman from " twelve miles west of Mount Isa, at the head of the Templeton River." This (*fide* local opinion at Mount Isa) is apparently the locality quoted elsewhere in this paper as Beetle Creek (a branch of the Templeton River), about twelve miles north-west of Mount Isa. The same locality is quoted by Chapman for the holotypes of *Bathyuriscus nitidus, B. olenelloides, Marjumia milesi, M. elegans* and *Milesia templetonensis.* The holotype of *Marjumia conspicabilis* is from " Shepherd Creek, near Miles Creek, north branch of the Templeton River" and the holotype of *Dikelocephalus dunstani* from the " Thornton River, N.W. Queensland." The types of these seven species, here included in *X. saint-smithi*, are in the collections of the Geological Survey of Queensland. Abundant material from Beetle Creek is contained in the collections of the University of Queensland, Queensland Museum, Geological Survey of Queensland, Australian Museum and others. In the University of Queensland Collection there are also specimens from Mingera Creek (on the road from Mount Isa to May Downs) from No. 1 bore, Alroy Downs, and from a hill top 16 miles north east of Yelvertoft Dip.

XYSTRIDURA SP.

An imperfect cranidium, with fainter furrows than *X. browni* and *X. saint-smithi* has been collected from the *Eurostina* Stage at the No. 4 bore on Alroy Downs (University of Queensland Collection).

Suborder PTYCHOPARIIDA Richter, 1932.

Family PTYCHOPARIIDAE Matthew, 1887.

Many genera of ptychopariids have been established recently by Walcott and others on species whose dorsal shields were well known. Many others have been based only on cranidia. It is a matter of considerable difficulty to interpret some of these latter genera. Similar types of cranidia appear at so many horizons in the

Middle and Upper Cambrian that, in the absence of complete specimens, it is sometimes scarcely possible to decide whether simple types (such as they are) persisted or whether such groups are homoeomorphs of several lineages following similar trends. Kobayashi (1935) recently has introduced an elaborate sub-family classification of these forms ; but such classifications are so apt to be changed when complete specimens come to light that I have preferred not to go into such details.

Two forms that occur on many horizons particularly concern us here—the square type of cranidium (the *Elathria* type) and the triangular form (the *Inouyella* type). It is of some interest to note how very similar are the early Middle Cambrian *Eurostina trigona* (Pl. XXII, figs. 11a, b) and the Upper Cambrian *Protemnites elegans* (Pl. XXII, figs. 12a, b, and 13).

Genus **LYRIASPIS** gen. nov.[24]

Genotype : *Lyriaspis sigillum* sp. nov.

Diagnosis : Cephalon with narrow convex rim. The glabella narrows anteriorly and is marked by the occipital furrow and two pairs of discontinuous, glabellar furrows. The fixed cheeks are relatively wide and inflated, with small, palpebral lobes and narrow, palpebral ridges. The anterior limb is of moderate width and convex. The anterior margins of the facial sutures are subparallel and the posterior margins slope obliquely. The free cheeks have genal spines.

There are thirteen or fourteen segments in the thorax. The pleura have wide furrows with subparallel sides and end obtusely.

The pygidium is small, with a prominent axis, and has the pleura marked with about three furrows on each side. The rim fringing the furrowed area is either very narrow or absent.

Remarks : *Lyriaspis* is very similar to *Elathria* Walcott (1924). The distinguishing features are the slightly wider fixed cheeks, the broadly furrowed pleura of the thorax and the absence of a prominent rim on the pygidium. *Ptychoparia* Corda, as restricted to the group of *P. striata* Emmrich, is another very similar form but it has a markedly larger pygidium. *Elathriella*, which is discussed below, has narrower fixed cheeks, larger eyes and more slender posterior lobes on the cranidium. A very close comparison may be made with *Proaulacopleura* Kobayashi (1936a). This genus from the early Upper Cambrian of Alabama[25] differs only in having a smooth glabella. None of the many other ptychopariid genera that have been defined in recent times are quite so similar as these four.

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[24] λύρα a lyre, ἀσπὶς a shield.

[25] It is associated with *Glyptagnostus*.

The genus is represented by Middle Cambrian species in Australia and Asia. I would place in *Lyriaspis* the Chinese *Ptychoparia kochibei* Walcott (1913, p. 132, pl. 12, fig. 5) and a group of Indian species described by Reed in 1910 (*P. spitiensis* Reed, *P. admissa* Reed, *P. stracheyi* Reed and possibly others).

There is a considerable variation in the genal spines in this genus. On *L. sigillum* they are very small. They are very large on *L. kochibei* ; while if *Ptychoparia maopoensis* Reed (1910, p. 28, pl. 3, figs. 20-25) is a *Lyriaspis*, the spines are taken to extremes in that member.

Frequently in species of *Lyriaspis* the impression of muscle scars are seen on the thorax. Generally they lie in the axial furrows or on the axis itself and are similar to those seen on *Ptychoparia* (s. str.).

The Australian, Indian and Chinese beds with *Lyriaspis* are all of Middle Cambrian age—and apparently early Middle Cambrian.

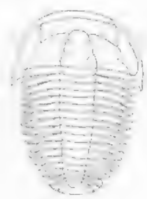
LYRIASPIS ALROIENSIS (Etheridge fil.)

(Pl. XXII, fig. 6.)

1915 Undescribed trilobite, Jensen, pl. 4, figs. 2, 3.
1919 *Ptychoparia alroiensis* Etheridge Jr., p. 385, pl. 40, fig. 8.
1922 *Ptychoparia merrotskii* Mitchell, p. 539, pl. 54, figs. 11, 12.

Etheridge's original description of this species is as follows :

"Cephalon semicircular (when perfect). Glabella obtusely conical, rounded in front, separated from the fixed cheeks and anterior limb by well-marked deep axial grooves ; two pairs of furrows, the basal pair circumscribing prominent basal lobes ; fixed cheeks, comparatively large, but less convex than the glabella ; palpebral lobes small, the connecting eye-lines, or ocular ridges, situated just in advance of the anterior pair of glabella furrows, anterior limb like the fixed cheeks gently convex, in the same plane as the glabella, separated from the anterior margin or fillet, which is cord-like and prominent, by a shallow groove ; neck-ring in its median portion comparatively thick, its groove well defined. Facial sutures in front of the palpebral lobes almost longitudinally straight, really very slightly convex, posterior to them curving downwards with a concave sweep and sharply outwards in the direction of the genal angles.



Restoration.

Thoracic somites fourteen ; axis elongately and narrowly obconical, gently convex ; axial grooves wide and open. Pleurae arched, angular in the middle line, each strongly grooved or furrowed, the proximal half horizontally so, the distal obliquely bent. Pygidium small, of two (or perhaps three) coalesced segments, and a small terminal appendage ; those of the pleurae deflected backwards to a slight degree ; posterior margin truncate and nearly straight."

Mitchell, apparently, was unaware of Etheridge's work ; for the same specimen was chosen as holotype for his *Ptychoparia merrotskii* described three years after Etheridge had established the species as *Ptychoparia alroiensis*.

The sharp convexity in the mid-pleural regions of the thorax gives this form a somewhat peculiar appearance. Perhaps it is best compared with *L. stracheyi* Reed sp. (1910, p. 21, pl. 2, figs. 8-13) in which, however, the courses of the anterior and posterior extremities of the facial suture are rather different. The Chinese *L. kochibei* Walcott sp. (1913, p. 132, pl. 12, fig. 5) is also somewhat similar but it is a flatter form with a wider cranidium. In many features *L. admissa* Reed sp. (1-10, p. 25, pl. 2, figs. 22, 23 ; pl. 3, figs. 1-4) may be closely compared ; but that species has an extra pair of faint furrows on the anterior portion of the glabella.

An interesting feature is to be noted about the locality of the holotype. This was stated by Etheridge to be eight miles east of Alroy Downs, in the Northern Territory. Some years ago I visited that locality but found no outcrops of Cambrian beds. Mr. Merrotsy, who found the specimen, had left the Northern Territory and I had no means of checking the occurrence. However recently Mr. Merrotsy has been in communication with me and has lent me the specimen. It is an external mould, impressed upon a piece of chert that has been chipped into an artefact by an aboriginal. Consequently the locality reference has little significance. Outcrops of similar cherts with cranidia of this species I have found at no great distance—eleven miles E.N.E. of Alroy Downs homestead at the crossing of Buchanan's Creek on the road to Alexandria.

Neither the figure given by Etheridge nor that in Mitchell's paper gives an adequate idea of the holotype. The figure published by Jensen is considerably better ; but since Jensen's paper is hard to obtain I have refigured the holotype.

Localities and horizon : The holotype came from eight miles east of Alroy Downs in the Northern Territory where it was not in situ. The specimen is in the private collection of Mr. A. L. Merrotsy. Other specimens, cranidia and portions of thorax, are in the collections of the University of Queensland from the *Dinesus* Stage at No. 1 Bore Alroy Downs (on the banks of Buchanan's Creek, 11 miles E.N.E. of Alroy Downs homestead).

LYRIASPIS SIGILLUM sp. nov.

(Pl. XXII, figs. 3-5.)

1936 *Xystridura sp. indet.* Tillyard, pl. D.

Diagnosis: Dorsal shield ovate. The cephalon is semicircular with a regularly rounded front and a narrow convex rim. The cranidium is rhomboidal in outline with a glabella that is about three-quarters of its length. The glabella

converges anteriorly, has a rounded front and bears an occipital furrow and three other pairs of discontinuous, backwardly-sloping furrows. Around it the axial furrow is prominently incised. The fixed cheeks are inflated and of moderate width. The palpebral lobes are small and are continued by slightly converging palpebral ridges. Anteriorly the facial sutures converge very slightly. Behind the eye they extend obliquely in a fairly straight line to near the genal angle. The anterior limb of the cranidium is narrow. The free cheeks are small, subtriangular and end in short genal spines.

Restoration.

There are fourteen segments in the thorax. The axis has well marked and well spaced rings and the pleura end very bluntly. In the axial furrows the muscle scars are often very prominently impressed. These muscle scars form almost continuous lines.

The pygidium is small and relatively smooth. The axis ends abruptly, is sharply truncated, and occupies more than one-third of the width of the pygidium.

Remarks : The most similar form is undoubtedly *L. alroiensis* which, however, is slightly wider, has broader fixed cheeks and a wider anterior limb.

In 1936 Tillyard figured a topotype of this species under the name *Xystridura sp. indet.* It is a most excellent figure but I suggest that a mistake has been made in the explanation. The figure which is about four times the size of the species is stated to be magnified two diameters.

Locality and horizon : The holotype and many other forms (in the University of Queensland Collection) come from the Middle Cambrian (*Dinesus* Stage) of Beetle Creek, 12 miles N.W. of Mount Isa.

Genus **CHANCIA** Walcott, 1924.

Genotype : *Chancia ebdome* Walcott.

CHANCIA VICENALIS sp. nov.

(Pl. XXII, fig. 7.)

Diagnosis : Cephalon unknown. The thorax consists of twenty segments. In the anterior portion the axis is one-fifth the width of the thorax and has well marked and regular furrows. The pleura are flat and straight as far as the fulcrum which is near the margin. Each pleuron is obliquely grooved by a very wide furrow that limits a narrow anterior rim of even width. The pleura end in short spines. The muscle scars of the thorax occur in the axial furrows.

The pygidium is small with a narrow convex rim. The axis is not strongly defined and has a number of very crowded furrows. Three wide, curving pleural furrows are arranged on each side, so disposed that they leave between each pair a narrow raised portion.

Remarks: Only one specimen, with typical ptychopariid features, is known and from it the cephalon is missing.

I have referred the form to *Chancia* which also has this unusual number of thoracic segments and which has very similar thoracic and pygidial structures. *Chancia* has been recorded from the late Lower Cambrian beds of Greenland (Poulsen, 1924) and the early Middle Cambrian of North America. No comparison can be made with the Greenland forms for they are known only from cranidia. Two of the american species however, the genotype (*C. ebdome* Walcott) and *C. evax* Walcott (1924 and 1925), are known from complete specimens. In *C. evax* there are 24 segments in the thorax and the pleura end more bluntly. But *C. ebdome* is very similar to *C. vicenalis*. It has twenty thoracic segments and their extremities are quite like those of the Queensland form. However the thorax is perceptibly wider in the american species. In all three species the course of the thoracic muscle scars is similar.

Locality and horizon: One specimen is present (the holotype) in the collections of the Geological Survey of Queensland from the North Templeton River. It was not found in situ. However, no fossiliferous beds have been found in this area other than those of the *Dinesus* Stage of the Middle Cambrian, which are locally well developed. It is probable therefore that the specimen came from such beds.

Genus **ELATHRIELLA** Poulsen, 1927.

Genotype: *Elathriella obscura* Poulsen.

Elathriella was established by Poulsen (1927, p. 276, pl. 17, fig. 35) for a species from Greenland that was based on two cranidia. No other forms were found associated with it so that the age of the genotype is uncertain. The beds in which it occurs are thin and overlie a formation with Middle Cambrian fossils.[26] Some considerable distance above are beds with a very late Cambrian fauna. Poulsen tentatively placed the *Elathriella* beds as Upper Cambrian or Lower Ozarkian, apparently basing his conclusions on his statement (p. 341) that "a very closely related species [to *Elathriella obscura*] occurs in Montana in strata, the age of which has not yet been fixed (Upper Cambrian or Lower Ozarkian)." However I understand from Professor Howell that these beds in Montana are now believed to be of Middle Cambrian age.

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[26] Poulsen correlated these latter beds with the Stephen Formation.

In Upper Cambrian beds of the Pituri Sandstones in Queensland there are trilobites whose cranidia are of the same type as *Elathriella obscura*. The agreement is so close that there is no valid reason for removing them from *Elathriella*. This raises the question of what is the range of the genus. It is possible, of course, that when more complete specimens of the genotype are known the Queensland forms might prove to be generically distinct. This is possible, but not indisputable; for the range involved is really not great. Even if the age of the Greenland beds should be Middle Cambrian (which remains to be proved) they must be in the upper half of the Middle Cambrian. It is not, then, a very great range for the genus to extend to the horizon in Queensland which I have placed, on available evidence (Whitehouse 1936), as approximately equivalent to the zone of *Orusia lenticularis*. I stress this advisedly; for *Elathriella* is a simple type of trilobite that might well have a range even greater than this.

Elathriella, interpreting it in light of the more complete Queensland specimens, is a typically ptychopariid genus. It may even be compared with some of the Olenidae, a family that, as I have indicated elsewhere (p. 217) I believe arose from Ptychopariidae. However the size of the palpebral lobes, the converging palpebral ridges, the type of posterior lobes on the fixed cheeks and the blunt pleura of the thorax all indicate the Ptychopariidae.

ELATHRIELLA PLEBEIA sp. nov.

(Pl. XXII, figs. 8, 9; pl. XXV, fig 16.)

Diagnosis: Cranidium subquadrate ornamented with very small scattered tubercles. The glabella is conical with rounded front, and extends for about two-thirds the length of the cranidium. On it the occipital furrow is prominently incised; and anterior to this there are two pairs of short, discontinuous glabellar furrows that bend backwards. The axial furrow is relatively deep. The fixed cheeks are narrow and convex. The palpebral lobes extend for rather more than one-third the length of the cranidium. They are united to the anterior glabellar lobes by converging, palpebral ridges. The anterior limb is convex and about one-sixth of the length of the cranidium. Separated from it by a furrow is the prominent, convex, anterior rim. The posterior lobes of the fixed cheeks are long and narrow. The anterior portions of the facial suture diverge slightly as they approach the anterior margin of the shield. The free cheeks are imperfectly known.

When the dorsal shield is of a length of 4·5 mm. the thorax has thirteen rather narrow segments. In the anterior portion of the thorax the axis (in the young stage

at least) is rather less than a quarter the width of the test. The axial portion of each segment has a wide and long articulating portion. The pleura are widely furrowed, the furrows having parallel sides, and end rather bluntly.

The pygidium is of moderate size with the axis of the pleura faintly furrowed.

Remarks: Cranidia have been collected showing a considerable variation in size from young forms (pl. XXII, fig. 9) to mature types (pl. XXII, fig. 8). Two specimens were obtained with the thorax attached, one of these having the pygidium present also. Other thoracic fragments were found that tentatively have been placed in this species.

The pygidium on the immature form figured has the sides steeply declined. The shape of this pygidium is triangular. Four furrows are shown on the somewhat abraded axis. The pleura have, on each side, four furrowed ribs extending completely to the margin.

The cranidia (such as that shown on pl. XXII, fig. 8) that are of the same size as the genotype show a remarkable agreement with it. It is difficult to select points of difference. There is a slight difference in the angle of the glabella and in the width of the anterior rim. Such distinctions, small as they are, appear to be sufficient to warrant separate specific recognition.

Locality and horizon: From the *Elathriella* Stage of the Pituri sandstones at the base of a hill immediately west of Tyson's bore on Glenormiston (University of Queensland Collection).

ELATHRIELLA SP.

(Pl. XXII, fig. 10.)

Associated with *Elathriella plebeia* is a form with slightly wider fixed cheeks. The glabella is similar and the angle of the palpebral ridges. The form is not sufficiently known to warrant a new specific name.

Locality and horizon: From the *Elathriella* Stage of the Pituri Sandstones at the base of a hill immediately west of Tyson's Bore, Glenormiston (University of Queensland Collection).

Genus **EUROSTINA** gen. nov.[27]

Genotype: *Eurostina trigona* sp. nov.

Diagnosis: Cranidium subtrigonal to subquadrate. The glabella is conical, with three pairs of discontinuous furrows anterior to the occipital furrow. Occipital ring wide. Axial furrow well incised. Free cheeks and anterior limb inflated, with a pair of faint antero-lateral depressions. Palpebral lobes small and prominent, continued by converging palpebral lobes. There is a prominent anterior rim.

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[27] εὔρωστος robust, in reference to the well moulded cranidium.

Remarks : *Eurostina* is apparently related to the other early Middle Cambrian genera, *Inouyia* and *Lorenzella*, from China. Of these *Lorenzella* is the more similar, but it does not have the prominent rim of *Eurostina*. *Ptychoparia tatiana* Walcott (see Walcott, 1913, p. 155, pl. 14, fig. 9), from the early part of the Kiu Lung and Ch'ang-hia Formations (basal Middle Cambrian), is another member of the genus.

EUROSTINA TRIGONA sp. nov.

(Pl. XXII, figs. 11a, b.)

Diagnosis : Cranidium subtriangular in shape. The glabella is plump and narrows anteriorly. In front of the prominent occipital furrow there are three pairs of discontinuous glabellar furrows, bending backwards towards the centre. The neck ring is wide. Fixed cheeks and anterior limb are inflated, the maximum convexity being immediately in front of the glabella and, laterally, opposite the centre of the glabella. Adjacent to the antero-lateral angles of the glabella there are small, slightly depressed areas in the fixed cheeks. The palpebral lobes are small, arcuate and raised into prominent rims, separated from the rest of the fixed cheeks by shallow grooves, and continued to the glabella by slightly arcuate, converging palpebral ridges. The anterior rim of the cranidium is a strong, rounded structure separated from the main part of the anterior limb by a furrow of equal width.

Remarks : This is the species that I referred to previously (1936, p. 74) as a *Lorenzella*, and possibly also as an *Inouyella*. From *E. tatiana* (Walcott), the only other species that seems to belong to the genus, it differs in the proportions of the glabella and in the more prominent groove behind the anterior rim. Also the palpebral lobes seem more definitely raised into rims.

Locality and horizon : One complete cranidium and three fragments have been collected from the *Eurostina* Stage of No. 4 bore on Alroy Downs (University of Queensland Collection).

Genus **PROTEMNITES** gen. nov.[28]

Genotype : *Protemnites elegans* sp. nov.

Diagnosis : Cranidium subtriangular in outline. The glabella is subconical in shape with an occipital furrow and two pairs of discontinuous glabellar furrows. The fixed cheeks are narrow, with small, centrally set palpebral lobes and converging palpebral ridges. The anterior limb is flat or slightly convex and the anterior rim is thickened centrally.

The pygidium is of moderate size with a prominently furrowed axis and faintly furrowed pleura. There is no pygidial rim.

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[28] προτέμνω to cut off in front.

Remarks : Trigonal forms of ptychoparian aspect occur on several horizons in the Cambrian. They are rather common in the Middle Cambrian, e.g. *Inouyella* and *Eurostina*. "*Conocephalites*" *vulcanus* (Billings 1861, p. 952) also is of this type and one of the Chinese forms figured by Walcott (1913, pl. 14, fig. 11a) as *Inouyia capax*. The genus *Pesaia* of Walcott and Resser (1924) continues the type into the Upper Cambrian. The peculiar medianly-thickened anterior rim and the rather wide and little inflated anterior limb render the present form rather distinct from any of the generically named groups in this series.

PROTEMNITES ELEGANS sp. nov.

(Pl. XXII, figs. 12a, b, 13.)

Diagnosis : Cranidium trigonal. The glabella is regularly conical in shape with a very narrow, rounded front. On it are the occipital furrow and two pairs of discontinuous, backwardly sloping furrows. The fixed cheeks are convex. They are widest at the posterior margin and narrow progressively forward. The palpebral lobes are small but prominently raised and are continued to the glabella by converging palpebral ridges. The anterior limb is very slightly convex (more prominently convex in the young stage). The anterior rim is short, very convex (particularly towards its centre) and slightly elevated.

The pygidium is transversely elongate. The axis has four prominent furrows and a small hemispherical termination. The pleura are flat with four faint curving furrows on each side. There is no differentiated margin.

Remarks : In the list of genera published in 1936 I recorded this form as *Pesaia* (?). It is clearly not a member of that genus which, while somewhat similar, has a narrower anterior limb and no glabellar furrows. I know of no other species that I would place in *Protemnites*.

Locality and horizon : An adult and a youthful cranidium and also an adult and a youthful pygidium are preserved on the one specimen of chert. This specimen, from the *Elathriella* Stage of the Upper Cambrian, was found in beds at the base of a hill immediately west of Tyson's bore on Glenormiston (University of Queensland Collection).

Family NEPEIDAE nov.

The genera *Acrocephalops*, *Alokistocare*, *Eldoradia*, *Bolaspis* and *Nepea*, which are discussed below, are apparently closely related to Ptychopariidae, in which family most of them previously have been placed. They seem to form a natural unit, with a community of morphological structures and occupying a limited portion of the Middle Cambrian. I propose therefore to group them as a separate family.

Genus **NEPEA** gen. nov.[29]

Genotype : *Nepea narinosa* sp. nov.

Diagnosis : Cranidium semicircular, with steeply descending sides. The glabella has three pairs of lateral notches. The frontal limb is highly inflated medially, the inflation being bounded laterally by grooves continued from the axial furrows. The anterior rim is narrow. The fixed cheeks are inflated, have small palpebral lobes and long, very narrow, posterior lobes.

Remarks : *Nepea* is related to a group of genera, in the early Middle Cambrian deposits of North America, that have a median boss in the frontal limb. *Acrocephalops* Poulsen (1927), *Alokistocare* Lorenz (1906), *Eldoradia* Resser (1935) and *Bolaspis* Resser (1935) are the other members of the group. Many of the North American species have, at times, been referred to *Acrocephalites* Wallerius (1895), of which the genotype is the scandinavian *Solenopleura* (?) *stenometopa* Angelin, a genus which, as Resser has suggested, may not be related.

In the inflation of the median boss and in the reduction of three features—the anterior rim, the palpebral lobes and the posterior lobes of the cranidium—*Nepea* reaches the acme of development for the group. The median boss is so pronounced and so definitely bounded by grooves developing from the axial furrows, that virtually it has the appearance of an inflated anterior lobe of the glabella. In this way superficially it recalls the glabella in the nepionic stages of certain olenids.[30] *Acrocephalops*, *Eldoradia* and certain new species that Resser (1938a) recently has placed in *Alokistocare* (notably *A. blainense*) are in this way the most similar. It may be that *Alokistocare blainense* should even be transferred to *Nepea*. The filament-like form of the posterior cranidial lobes is not matched by the type species of any of the genera listed above ; but certain species, for instance *Alokistocare* ? *americanum* Walcott sp. (1916, p. 177, pl. 24, fig. 2), have a similar tendency. The wire-like anterior rim is not pecular to *Nepea*. *Bolaspis*, *Eldoradia* and *Acrocephalops* have this also.

Perhaps the most similar genus is *Eldoradia* ; but *Nepea* differs from it, and indeed from all these other genera, in the filament-like form of the posterior lobes of the cranidium.

Most genera in this group have a tuberculate ornament. The specimens of *Nepea narinosa* have been found in sandstone ; so that the surface ornament is not known.

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[29] *νήπιος* childish.

[30] Compare, for example, the figures given by Lake (1908, pl. 6) of *Olenus mundus*. It is for this reason that the name *Nepea* has been chosen.

Alokistocare, *Bolaspis*, *Eldoradia* and *Acrocephalops* seem all to occur in the early Middle Cambrian of North America. The stratigraphical position of some species is still apparently in doubt; but from my reading I have the opinion that the group generally is typical of the *Glossopleura* faunas of North America.

NEPEA NARINOSA sp. nov.

(Pl. XXII, 15a, b and 16.)

Diagnosis: Cranidium semicircular. The glabella is narrow and slightly convergent, with a straight front. The occipital furrow is continuous. Three glabellar furrows immediately anterior to this are deeply incised but discontinuous. The frontal limb is swollen to a subcircular bulbous structure immediately in front of the glabella, the lateral grooves bounding the structure being continuous from the axial furrows. Immediately in advance of this is the marginal rim, reduced to a very narrow border. Fixed cheeks are wider than the glabella, inflated and prominently deflexed on their lateral margins. Palpebral lobes are small, raised very prominently from the surface of the fixed cheeks, and situated on the anterior half of the cranidium, distant from the glabella. The posterior limb of the facial suture is embayed. The palpebral ridges are faint, extending horizontally from the anterior glabellar furrow to the palpebral lobes. The occipital ring is narrow, with a faint median boss. The posterior borders of the cranidium are the same width as the occipital ring and extend laterally to form very narrow postero-lateral lobes. Free cheeks and hypostome are as yet unknown.

The thorax had at least ten simple, narrow segments, the pleurae on each side being almost three times as wide as the axis.

Pygidium unknown.

Remarks: No other species has been described that I would refer to this genus. However in Victoria a form, generically if not specifically identical with *N. narinosa* and not yet described, also occurs in beds containing *Amphoton*.[31] Many of the American species are still not sufficiently known for a correct generic placing. As noted above *Alokistocare blainense* Resser (of which the posterior cranidial lobes have not been figured) may be a member of this genus.

Locality and horizon: From the *Amphoton* Stage at " Split Rock " on Waroona Creek, at the crossing of the main road from Camooweal to Mount Isa. Holotype and other specimens in the collections of the University of Queensland.

[31] I have referred previously to this association (Whitehouse 1936, p. 73).

Family SOLENOPLEURIDAE Angelin, 1854.

Genus **ASTHENOPSIS** gen. nov.[32]

Genotype : *Asthenopsis levior* sp. nov.

Diagnosis : Cephalon wide, with a short, conical glabella that is faintly marked with two pairs of glabellar furrows. Occipital ring well defined. The fixed cheeks are wide, with narrow palpebral ridges leading to small palpebral lobes situated either centrally or slightly behind the median line. Pre-glabellar field and marginal rim well defined. The free cheeks bear genal spines rising rather abruptly from the genal angles.

There are fourteen segments in the thorax, the pleura of which are well furrowed and terminate either bluntly or in obtuse spines.

The pygidium is small and non-spinose, with the axis prominently segmented and at least two pairs of prominent, rounded, pleural ribs.

The test is ornamented with tubercles, usually of two sizes (larger tubercles scattered among smaller), that sometimes may be minute.

Remarks : *Solenopleura*, in the common usage of the name, is a genus of many species. The genotype (selected by Vogdes, 1925) is *Solenopleura holometopa* Angelin. This is a form in which the glabella, relatively, is large and the fixed cheeks and pre-glabellar field are accordingly narrow. More abundant than such forms are species with a small, conical glabella, wider fixed cheeks and prominent pre-glabellar field. Among European species are *Solenopleura brachymetopa* Angelin and *S. applanata* (Salter). It is for this group that the name *Asthenopsis* is proposed. Only a few of the many species that may be included are known from complete tests. *A. levior* is chosen as the genotype, rather than one of the European species, since it is known from whole and uncrushed specimens.

Little can be said at present about the variability of the thorax and pygidium ; but the following variations of cephalic structures may be listed :

1. There is a papillate ornament on the test,[33] particularly on the cephalon, that often is resolved into papillae of two sizes. This ornament varies from relatively coarse (*A. canaliculata* Angelin sp.) to microscopic (*A. levior*).

2. Glabellar furrows vary from moderately incised (*A. canaliculata*) to very faint (*A. levior*).

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[32] ἀσθενής feeble, ὄψις sight—in reference to the small eyes.

[33] Among the solenopleurids the papillation seems to be more strongly marked on the test than on the internal mould, which may account for the differences between the figures given by Grönwall (1902) and Walcott (1913) for the ornamentation of *Solenopleura holometopa*.

3. The palpebral ridge is narrow. In some forms (*A. canaliculata*) it is prominently raised ; on others (*A. levior*) it is so faint that usually it can be seen only with a lens.

4. The palpebral lobes may be central (*A. applanata* Salter sp.) with palpebral ridges normal to the axis, or the lobes may be slightly posterior (*A. brachymetopa* Angelin sp.) with the ridges converging obtusely upon the glabella. These ridges are sometimes straight, sometimes slightly arcuate.

5. The genal spines vary from prominent (*A. levior*) to small structures (*A. applanata*), but they arise rather abruptly from the genal angles.

6. On some forms (*A. levior*) there is a slight tendency to develop radial wrinkles on the pre-ocular regions.

Kobayashi (1935, pp. 258-289), who seems to regard all the Asiatic species as generically distinct from those of the Atlantic Province, transferred many of the Chinese species that Walcott had placed in *Solenopleura* to a new genus, *Solenoparia*. Endo and Resser (1937) have followed him in this usage. The genotype that he chose for *Solenoparia* was *Ptychoparia* (*Liostracus*) *toxeus* Walcott, a form with large palpebral lobes that Walcott, I believe correctly, excluded from Solenopleuridae. Most of Walcott's Chinese species of *Solenopleura*, it seems to me, agree with or are very close to *Asthenopsis* and are distinct from *Solenoparia*.

In passing it may be noted that Kobayashi (1935, p. 265) has referred the South Australian species *Conocephalites australis* Woodward (1884, p. 344, pl. xi, figs. 2a, b) to *Solenopleura*. That species, however, is a Lower Cambrian form more akin to *Protolenus*.

Asthenopsis, as defined above, is a Middle Cambrian genus known in the Atlantic Province of Europe and North America and also in Asia and Australia. In Europe it is found from the zone of *Paradoxides hicksi* to the zone of *Paradoxides forschammeri*.

ASTHENOPSIS LEVIOR sp. nov.

(Pl. XXII, figs. 17-20.)

Diagnosis : Outline regularly oval. The surface of the test is ornamented with microscopic tubercles of two sizes (large tubercles scattered among small). These tubercles, toward the posterior end of the thorax, tend to be restricted to the axial region.

The glabella is short and conical, extending for about two thirds the length of the head. On it the occipital furrow is well marked and continuous, and there are two pairs of extremely faint, discontinuous furrows extending only a short distance from the axial furrow. The fixed cheeks are wide and inflated, with small, post-central palpebral lobes and extremely faint palpebral ridges. The facial sutures converge slightly anteriorly, while posteriorly they reach the margin a little behind the genal spines. The pre-glabellar field is slightly inflated and, like the free cheeks, bears faint radial wrinkles. The anterior rim is moderately flat and wide. Free cheeks are small, with prominent, stout, genal spines that do not continue the curve of the anterior margin but extend obtusely to it.

Restoration.

There are fourteen segments in the thorax. The rings on the axis are cord-like. The pleura are deeply furrowed, markedly geniculate and terminate in obtuse spines.

The pygidium is approximately one seventh of the total length. On it there are three prominent axial rings and a posterior axial lobe. On the pleura there are four pairs of arcuate ribs, increasing in size outwards but terminating some distance before the margin. The posterior margin is straight or slightly concave.

Remarks : As noted above *A. levior*, in many of its features, is at one extreme of the variations shown by the genus. Its papillose ornament is remarkably fine, its glabellar furrows are extremely faint, the genal spines are stouter than in most species, the eyes are in a post-central position and there is a slight suggestion of radial wrinkles on the pre-glabellar field and the free cheeks. In this *combination* of characters it is distinct from the other species of the genus.

Locality and horizon : Very common in the limestones of the *Papyriaspis* Stage at the road crossing of V Creek, between Undilla and Thorntonia (University of Queensland Collection).

Family OLENIDAE Burmeister, 1843.

Subfamily PAPYRIASPINAE nov.

The four genera *Pianaspis* Saito and Sakakura (1936, p. 114), *Papyriaspis* gen. nov., *Rhodonaspis* gen. nov. and *Hedinia* Troedsson (1937, p. 56) have the essential features of the Olenidae and possess also certain features in common that stamp them as a group distinct from the several subfamilies that have been proposed. For them I suggest the subfamily name Papyriaspinae. Through this group, at

present known only in the Australian-Asiatic Province, the Olenidae may be traced back to the early part of the Middle Cambrian. The four genera are characterised particularly by the flatness of the test and by the relatively narrow axis.

Until 1936 no definite olenid was known in beds earlier than the Upper Cambrian. The ancestors of the family had been sought in diverse groups. Of recent writers Swinnerton (1915) derived them from Conocoryphidae. Westergaard (1922), after careful zonal studies, traced them back to *Liostracus costatus* Angelin, a species whose relationships still are not well defined.[34] Warburg (1925) has made suggestive remarks about a relationship between Olenidae and Ptychopariidae without committing herself to a belief in any direct derivation. Poulsen (1927) considered an origin in Ptychopariidae but only doubtfully. Richter (1932) supposed Ellipsocephalidae to be the parent family. Finally Kobayashi (1936a) has revived the idea of an origin in *Protolenus* and has suggested *Annamittia* as a possible link. The very name *Protolenus* that Matthew gave to a Lower Cambrian trilobite in 1892 has tended, I think, consciously or unconsciously, to draw undue attention to that genus whose test still is imperfectly known.

Most writers on the olenids, no matter what their beliefs have been in such origins, have been impressed by the close similarity between Olenidae and Ptychopariidae. There is hardly a feature of the test that, if one regards it as typical of the one family, cannot be matched in some genus of the other. Within each family there is a particularly wide variation in characters.[35] Possibly because of this latitude most workers have been inclined to regard resemblances as homoeomorphic repetitions and few who have written about lineages have linked the two families directly.

Hedinia occurs in the Upper Cambrian of T'ien-Shan; *Rhodonaspis* is from the early Upper Cambrian in Australia; *Papyriaspis* occurs at the top of the Australian Middle Cambrian; while *Pianaspis* comes from the early Middle Cambrian of Korea. Tracing the family back in this way the relationships with Ptychopariidae seem even more to be emphasised. For instance the axis in these four genera is narrower than in Oleninae and approximates more to the proportions of the ptychopariids. Also the types of thoracic pleura are morphologically intermediate between typical Ptychopariidae and Oleninae—although *Rhodonaspis* has long, terminal, pleural spines, as in typical olenids, *Papyriaspis* has blunt pleura, as in Ptychopariidae, while *Pianaspis* and *Hedinia* represent an intermediate stage with short spines.

[34] Many authors have suggested, for instance, that *Liostracus costatus* is a ptychopariid genus and not a member of *Liostracidae*. It may even be a true olenid.

[35] In Olenidae this variation goes to such an extreme that in *Jujuyaspis* Kobayashi (1936a, p. 89) it produces even a genus with proparian facial sutures.

The resemblance of the earliest genus, *Pianaspis*, to the contemporaneous ptychopariid *Lyriaspis* is particularly striking.[36]

I would suggest that, early in the Middle Cambrian, the olenids arose from Ptychopariidae, possibly from *Lyriaspis*, and, as Papyriaspinae, have not yet been found in Middle Cambrian deposits beyond the Australian-Asiatic Province. Then, in the Atlantic and South American seas in the Upper Cambrian, they evolved into other subfamilies—Oleninae, Leptoplastinae, Triarthrinae.

Genus **PAPYRIASPIS** gen. nov.[37]

Genotype : *Papyriaspis lanceola* sp. nov.

Diagnosis : Test flat and thin. Outline regularly subovate. The axis is relatively narrow—about one-fifth of the total width. Cephalon is one-third of the total length, with a short, tapering glabella marked by the occipital furrow and two or three pairs of glabellar notches that do not reach the axial furrow. The occipital ring is markedly wider than the first thoracic segment. Fixed cheeks are wide. Palpebral ridges are narrow, leading to small palpebral lobes. The pre-palpebral region is marked by fine radial wrinkles. The free cheeks are wide, with prominent genal spines.

The thorax has eighteen segments with flat, narrow, widely grooved pleura ending bluntly.

The pygidium is semicircular, with a non-spinose border. Its axis is well segmented. The pleura are flat and marked by wide grooves.

Remarks : *Hedinia* Troedsson is the most similar genus. The two genera agree in general shape, in the lateral dimensions of the axis, in the notched glabella that is notably wider than the axis of the thorax, widely furrowed thoracic pleura that end in short spines and in the non-spinose rim of the pygidium. *Papyriaspis* has, however, a shorter and more tapering glabella, a continuous occipital furrow and a larger pygidium. *Pianaspis* Saito and Sakakura has lateral notches on the glabella, relatively a wider thoracic axis, and more deeply furrowed thoracic pleura.

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[36] Saito and Sakakura (1936, p. 116), when erecting the genus *Pianaspis*, compared it closely with *Ptychoparia kochibei* Walcott, a member of *Lyriaspis*.

[37] πάπῡρος papyrus, ἀσπὶς a shield—in reference to the thin, parchment-like nature of the test.

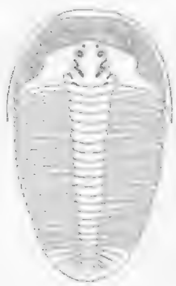
PAPYRIASPIS LANCEOLA sp. nov.

(Pl. XXIII, figs. 1-8.)

Diagnosis : Test flat, subovate, the length nearly twice the width.

The cephalon is transversely elongate. The cranidium is rhomboidal in outline, tapering anteriorly. The glabella narrows anteriorly and is about two-thirds the axial length of the cranidium. On it the occipital furrow is continuous and there are four pairs of discontinuous glabellar notches. The first two pairs (anterior) are small circular depressions not connected with the axial furrow. The third pair consists of long, narrow pits, extending obliquely backwards but connected to the axial furrow by curious anterior extensions that are discordant in direction with the main pits. The fourth pair have sinuous courses and arise obliquely from the axial furrow as if to form occipital lobes ; but they are not continuous with the occipital furrow, although immediately anterior to the occipital furrow there are two small circular depressions, in line with these fourth furrows and probably related to them. The postero-lateral margins of the glabella in this way are rather irregular.

The fixed cheeks are relatively wide and are crossed by very narrow palpebral ridges that converge at an angle of approximately 150° at the anterior end of the glabella. The palpebral lobes are small and semicircular, situated immediately posterior to the median line. Fine, radial, anastomising wrinkles cover the pre-glabellar field. The anterior rim is narrow and well defined. The facial sutures converge anteriorly from a region behind the eyes ; but the posterior limbs of the facial suture extend obliquely outwards. The free cheeks have short genal spines. Like the pre-glabellar field they are marked by radial wrinkles.



Restoration.

The thorax consists of eighteen segments. The axis is narrow (about one quarter the total width), it tapers uniformly to the rear, and the first segment of it is markedly narrower than the occipital ring. The pleura are flat, very long and narrow, presenting a lath-like appearance ; they are grooved by wide, shallow furrows with sub-parallel sides and they terminate bluntly.

The pygidium is semicircular in outline and is about one eighth of the total length of the test. There are four narrow rings on the axis and a large posterior lobe. The pleura are flat and are marked by five pairs of long, narrow, shallow furrows with subparallel sides.

Remarks : No other species of the genus is yet known. I have several dorsal tests that are complete but for the free cheeks, and numerous fragments of the species. The holotype is 39 mm. long ; but from comparative measurements of fragmental material it would seem that specimens may reach a length of 50 mm.

On plate XXIII, figure 4, a small form is illustrated that is approximately 20 mm. long. On such forms the pre-glabellar field is smoother, and rather more inflated than on the larger forms and there is little trace of the fourth (posterior) pair of glabellar furrows. However, I believe these to be immature forms of this species. Comparable differences between young and mature forms occur in the related genus *Hedinia* (Troedsson, 1937).

Locality : From the *Papyriaspis* stage at the crossing of V Creek, between Undilla and Thorntonia (University of Queensland Collection).

Genus **RHODONASPIS** gen. nov.[38]

Genotype : *Rhodonaspis longula* sp. nov.

Diagnosis : Cranidium wide. The glabella is narrow, it has subparallel sides and is marked by the occipital furrow and two or three pairs of discontinuous glabellar furrows that arise from the axial furrow. The anterior limb and the fixed cheeks are wide. Palpebral ridges extend, at right angles to the axis, from the anterior lobe of the glabella to the arcuate palpebral lobes.

The thorax consists of about nineteen segments, with narrow axis and widely furrowed pleura that terminate in spines.

The pygidium is small with sharp pleural ridges and marginal spines.

Remarks : The notches of the glabella and the narrow axis of *Rhodonaspis* suggest a close relationship to *Papyriaspis* and *Hedinia*. The genus is sufficiently distinct from them in the features of the glabella, the palpebral ridges and in the long, marginal spines of the thorax and pygidium. In the development of these spines and in certain features of the head comparison may be made with several genera of Oleninae, notably *Olenus* and *Eurycare* ; although the assemblage of characters indicates Papyriaspinae as the appropriate subfamily.

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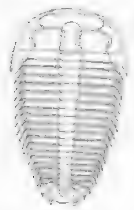
[38] ῥόδον a rose, ἀσπὶς a shield—in reference to a resemblance to a serrated rose leaf.

RHODONASPIS LONGULA sp. nov.

(Pl. XXIII, fig. 9.)

Diagnosis : Cranidium wide and flat. The glabella has strictly parallel sides and broadly rounded front ; and, with the occipital ring, is about twice as long as it is wide. The occipital furrow is wide, prominent and continuous. In front of it are two pairs of wide glabellar furrows extending only a short distance on each side from the axial furrow, thus giving the glabella a notched appearance ; anteriorly there is a trace of a pair of circular pits, not in contact with the axial furrow. The fixed cheeks are very wide and flat. The palpebral lobes are arcuate and have a narrow but well defined and very uniform rim. This rim continues anteriorly beyond the region of the lobes. Palpebral ridges are present, at right angles to the axis, connecting the anterior end of the palpebral lobe to the middle portion of the anterior glabellar furrow.



Restoration.

The thorax consists of nineteen segments and is lanceolate in outline. The axis tapers uniformly. In the anterior half of the thorax it is about half the width of a pleuron, but towards the rear it is relatively wider. Each segment of the axis has a median transverse ridge. The pleura are flat. Each is marked by a very wide furrow with parallel sides as far as the fulcrum. The pleura end in narrow recurved spines.

The pygidium is very small. The axis, which has three furrows, extends almost to the posterior margin. The pleura have one pair of faint furrows on the interior portion but otherwise they are smooth. They have, on each side, three reflexed, marginal spines.*

Locality and horizon : One specimen, the holotype, is in the collection of the University of Queensland, from about two miles south of Tyson's Bore on Glenormiston (*Rhodonaspis* Stage).

RHODONASPIS PROSECTA sp. nov.

(Pl. XXIII, figs. 10-12.)

Diagnosis : Cranidium quadrate in outline. The glabella is long with parallel sides and an abruptly truncated front. Anterior to the occipital furrow there are three pairs of equally spaced, discontinuous and sharply incised furrows. The

* The pygidium as drawn in the text-figure is slightly incorrect. The axis is too short and two tiny posterior spines have been omitted.

posterior pair slope backwards towards the axis. The two anterior pairs are at right angles to the margin. The fixed cheeks are wide, expanding considerably in the palpebral regions. The anterior portion of the facial suture are parallel. The palpebral lobes are sub-semicircular with a uniform, narrow, raised rim. They are continued to the glabella by palpebral ridges of similar width to the palpebral rim. These ridges are in line and parallel to the anterior margin of the head. The anterior limb is narrow and convex and is succeeded by a narrow, raised, cord-like anterior rim.

The pygidium is sub-semicircular in outline. The axis is conical, prominently raised, and has five or six rings on the axis. The flanks bear three sharply-ridged, radiating, ribs that terminate in spines.

Remarks : This species differs from *R. longula* in its shorter anterior limb and in the greater prominence of the pygidial ribs.

Locality and horizon : From the *Rhodonaspis* Stage, at the western base of Polly's Lookout, Glenormiston (University of Queensland Collection).

RHODONASPIS SP.

(Pl. XXIII, fig. 13.)

Several fragments of a species have been found with the following features :

Cranidium imperfectly known. The anterior margin is rounded. The glabella is long, slightly tapering and is not prominently bounded anteriorly. The two posterior pairs of discontinuous, glabellar furrows slope backwardly towards the axis. The anterior pair are at right angles to the margin. The anterior limb is moderately wide and covered with fine radiating wrinkles.

It is distinct species in a number of features—the slow tapering of the glabella, the slight obliquity of the second pair of glabellar furrows, the indefinite boundary to the front of the glabella, and the rounded anterior margin of the cranidium. However the fragments, if figured, would make it difficult to picture the species, so that I postpone giving it a name until more complete specimens are collected.

Locality and horizon : From the *Rhodonaspis* Stage, five miles north of the Twenty Mile Bore, Glenormiston (University of Queensland Collection).

Subfamily OLENINAE Kobayashi, 1935.

Genus **OLENUS** Dalman, 1827.

Genotype: *Entomostracites gibbosus* Wahlenberg.

OLENUS (?) **SP.**

(Pl. XXIII, fig. 14.)

A cranidium has been obtained from the *Elathriella* Stage that tentatively may be placed in the genus *Olenus*. It is imperfectly preserved. The wide and long anterior limb, the fairly horizontal palpebral ridges, the presence of three pairs of glabellar furrows (instead of two) before the occipital furrow, suggest that it is not an *Elathriella*. Unfortunately the course of the facial suture behind the palpebral lobes is hardly known. The form, from such of its features as are known, agrees fairly well with *Olenus* and I leave it there for the present. Olenids are recorded from several areas in the pacific province. Kobayashi (1936a) has recently reviewed all these records.

Locality and horizon: From the *Elathriella* Stage of the Pituri Sandstones at the base of a hill immediately west of Tyson's Bore on Glenormiston (University of Queensland Collection).

A somewhat similar and indefinite fragment has been found in the beds of the *Glyptagnostus* Stage, 16 miles south of Glenormiston homestead.

Family ANOMOCARIDAE Poulsen, 1927.

Genus **ANOMOCARE** Angelin, 1854.

Genotype: *Anomocare laeve* Angelin.

ANOMOCARE CONFERTUM sp. nov.

(Pl. XXIII, figs. 22-28.)

Description: The cranidium is of average size for the genus. The glabella which slowly tapers anteriorly has a rounded front, and its length is about twice its maximum width. The occipital furrow is distinct. Two other glabellar furrows are indicated slightly on each side. The neck ring has no median spine. The anterior limb is slightly concave, extending to a distance equal to about one-third the length of the glabella. Fixed cheeks are semicircular, with regular palpebral lobes impinging at each end upon the glabella. The width of each fixed cheek is slightly less than the maximum width of the glabella. The postero-lateral limbs of the fixed cheeks are very small and rudimentary. Facial sutures converge towards the anterior ends of the anterior portion of the glabella and almost impinge upon it where they meet the anterior ends of the palpebral lobes.

Restoration.

The free cheeks have narrow, flattened lateral and posterior borders, and short, acute, genal spines.

Thoracic segments are narrow.

The pygidium has an axis that narrows but becomes more convex posteriorly. Axial furrows are not very prominent, while the furrows on the pleural lobes become merely incised lines. A smooth, regular margin, inflected at the posterior apex, is present, the uniform width of which is approximately equal to the maximum width of each pleural lobe.

The hypostome is elongate and oval with the anterior lobe highly inflated and occupying about two-thirds of the total area. The posterior lobe merges into the lateral borders. Maculae are absent.

Remarks : The genus *Anomocare* was originally described from Scandinavia. Since then it has been recorded in Siberia, Bennett Island (north of Siberia), England, Sardinia, North America, China, Tonkin, India and Persia. The forms from Bennett Island, described by Holm & Westergaard in 1930, are close to the genotype ; but it seems hardly likely that any of the species from countries other than this and from Scandinavia can belong to *Anomocare* in its restricted sense. Kobayashi and also Resser & Endo have recently removed many of the eastern asiatic species to other genera. In view of this it is curiously interesting to record now from Australia a species that *is* close to the genotype.

The specific features have been determined from a number of fragments. *A. confertum* has a cranidium in which the palpebral lobes impinge upon the glabella, and the facial sutures join the anterior portions of the lobes near these points of contact. This feature is seen also in *A. excavatum* Angelin,[39] *A. extornatum* Holm and Westergaard (1930, pl. 4, figs. 20-23) and *A. sibiricum* Holm and Westergaard (1930, p. 17, pl. 2, figs. 15-20, pl. 3, figs. 1, 2). From these three species *A. confertum* is easily distinguished by several minor features, for instance its more acuminate glabella. Except for this aspect of the facial suture and for the somewhat shorter frontal limb, the cranidium of *A. confertum* is very similar to that of the genotype, *A. laeve* Angelin, which is probably the most closely allied form.

The inflected margin of the pygidium is a characteristic feature of this species. In this respect and in other pygidial features *A. laeve*[40] is again the most similar form.

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[39] Angelin, 1854, p. 25, pl. 18, fig. 3. See also Holm & Westergaard, 1930, p. 16, pl. 2, figs. 1-14, pl. 4, figs. 19-21.

[40] That is, in the interpretation of Holm & Westergaard. There has been some disagreement about what is the pygidium of *A. laeve*. Grönwall (1902, p. 141, pl. 4, fig. 9), and following him Walcott (1913, pl. 17, fig. 1) have figured a pygidium supposed to belong to this species ; but Holm & Westergaard (1930, p. 17, pl. 4, fig. 18) disagree with this interpretation and have figured the pygidium that, according to Westergaard, is associated with the typical cranidia at the type locality.

The hypostome has the characteristic inflated form for *Anomocare* and may be compared particularly with that of *A. sibiricum.*

Locality and horizon : Holotype and several other specimens in the University of Queensland Collection from the *Anomocare* Stage, five miles east of Harris Creek on the old main road from Camooweal to Burketown, *via* Thorntonia Station (52 miles from Camooweal).

ANOMOCARE (?) ANGUSTUM sp. nov.

(Pl. XXIII, fig. 21.)

Diagnosis : Cranidium narrow. Glabella long and tapering, with straight sides and rounded front. The occipital furrow is sharply incised at the sides but very faint in the centre. The posterior glabellar furrow proper is reduced to two depressions. Anteriorly there is a faint, sub-continuous furrow. The frontal limb is slightly concave, bounded by a narrow, anterior border. The fixed cheeks are narrow. Palpebral lobes are small, near the middle of the glabella. The anterior branches of the facial suture are divergent ; the posterior branches are short and, apparently, sub-normal to the posterior margin.

Remarks : This species is apparently a member of Anomocaridae, but the palpebral lobes are too small for a member of *Anomocare* itself. It occurs in beds immediately older than those with true *Anomocare.* Only the one cranidium has been found ; and since there is no properly defined genus to accommodate it, the species may be left provisionally in *Anomocare,* pending the discovery of more material.

Attention may be called to the casual resemblance the species bears to the earlier forms of *Proasaphiscus,* near the base of the Middle Cambrian, particularly to *P. ephori* (Walcott), (see 1913, p. 190, pl. 18, figs. 5) and *P. centronatus* Endo and Resser (1937, p. 259, pl. 37, figs. 17-20).

Locality and horizon : From limestones of the *Papyriaspis* Stage at the road crossing of V Creek, between Undilla and Thorntonia (University of Queensland Collection).

Genus EUGONOCARE gen. nov.[41]

Genotype : *Eugonocare tessellatum* sp. nov.

Diagnosis : Cranidium subquadrate. The glabella is subrectangular with occipital furrow and two pairs of discontinuous furrows. The palpebral lobes are about one-half the length of the cranidium, well separated from the glabella and connected to it by faint palpebral ridges. The anterior limb is moderately wide and

[41] εὐγώνιος with regular angles, κάρη the head.

convex with a surface covered with very fine radial wrinkles. The anterior border is narrow, convex, and with a parallel furrow behind. Facial sutures have the anterior portion more or less at right angles to the anterior margin of the cephalon.

The pygidium is slightly smaller than the cranidium. Its axis has five or six rings and the pleura are faintly furrowed. There is a smooth, flattened border.

Remarks : In its pygidial features and in many of the aspects of the head *Eugonocare* resembles *Anomocare* ; but the squat glabella, the straighter facial sutures and the raised anterior border are cranidial features that sufficiently distinguish it.

Poulsen (1927, p. 325) has suggested that Anomocaridae arose from Ptychopariidae by the forms becoming " isopygous and in having fewer thoracic segments, and furthermore, the palpebral lobes are considerably larger than in that family." I also am inclined to this view. Poulsen stresses, in addition, the wide, strongly concave rim of the head of Anomocaridae and the strongly furrowed pygidium with its broad, concave border. It is in these features, with the exception of the number of thoracic segments (of which I have no knowledge) and the concavity of the anterior limb, that *Euganocare* differs from certain typical members of Ptychopariidae. (It should be noted, by the way, that the anterior limb of *Anomocare* is not always concave—the genotype *A. laeve* is somewhat convex).

Many of the American and Asiatic forms that have been placed in *Anomocare* and *Anomocarella* and which recently have been grouped into other genera[42] by various authors may represent similar offshoots from ptychoparian stock. The development of isopygous forms with wide-bordered pygidia and increased eyes seems to me to be a normal tendency with Ptychopariidae. If this be so a number of family names will be needed in future to accommodate whatever natural groups may be recognised. For the present, however, until more is certain of lineages, I am placing *Eugonocare* in Anomocaridae. Kobayashi (1935), it may be noted, already has employed a considerable family nomenclature for such forms, although his grouping indicates that he does not regard them as having a common ancestry in Ptychopariidae.

Pertinent comparison may be made with *Anomocarella* Walcott, *Lioparia* Lorenz, *Tollaspis* Kobayashi and *Manchuriella* (Resser and Endo ms.) Kobayashi, which genera, with *Anomocare*, seem to me to be the most similar members of this group. *Anomocarella*, in its restricted sense, is rather similar in its pre-glabellar structures ; but it has no glabellar furrows and the facial sutures are more sinuous. *Lioparia* has a concave anterior limb and smaller palpebral lobes. *Tollaspis*[43] is the

[42] Such genera as *Anomocarella* (sensu stricto), *Lioparia*, *Coosia*, *Kingaspis*, *Eymekops*, *Koptura*, *Manchuriella*, *Tollaspis* and *Glyphaspis*.

[43] As mentioned elsewhere in this paper (p. 228) it is probable that *Tollaspis* as defined by Kobayashi was polyphyletic. My remarks apply to the genotype, *Anomocare pavlowskii* Schmidt.

genus that is perhaps most similar to *Eugonocare*. There is a smaller quadrate outline to the cranidium and glabella, similar anterior border and glabellar furrows, but the anterior limb is narrower. The pygidium of this genus has not yet been figured unless possibly it is represented by the specimen figured by von Toll (1899, pl. 2, fig. 11) as *Bathyuriscus howelli* Walcott. *Manchuriella* is generally similar but it has a narrower cranidium and a rather longer glabella.

EUGONOCARE TESSELLATUM sp. nov.

(Pl. XXIII, figs. 15-18; pl. XXV, fig. 7, b.)

Diagnosis: Cranidium subrectangular, the width slightly greater than the length. The glabella narrows only very slightly, has an abruptly truncated anterior and thus has a subrectangular form. With the occipital ring it is three-quarters the length of the cranidium. The occipital furrow is rather shallow. In front of it are two pairs of discontinuous glabellar furrows that slope backwards at a prominent angle. The axial furrow is prominent. Beyond it the free cheeks and the anterior rim arise convexly. The free cheeks are wide, each almost as wide as the glabella. The facial sutures extend more or less at right angles to the anterior and posterior margins of the cephalon, and are only slightly modified by the palpebral lobes. These lobes are between one-third and one half the length of the glabella, are narrowly bordered and are continued to the anterior angles of the glabella (sloping forward at a slight angle), by faint palpebral ridges. The anterior rim is convex in its posterior portion but changes into a groove immediately behind the anterior border. This border is sharply defined and convex.

The pygidium is sub-semicircular and has a raised anterior rim. The axis is distinct but is not prominently inflated and bears four raised narrow rings (dividing the fused segments) that decrease in prominence posteriorly. The pleura bear faint ridges, extending from the axial rings for a short distance. The portion of the pygidium (axis and pleura) that have these traces of segmentation is somewhat markedly triangular. Beyond it and rather abruptly separated from it there is a wide smooth border set at an obtuse angle to the furrowed part.

Remarks: I would call attention to the Persian form figured by King (1930, p. 319, pl. 17, fig. 5) as *Anomocare subquadratum* (Dames). This species which probably is distinct from Dames' form, is more similar to *E. tessellatum* than any other I have seen and may be congeneric.

Locality and horizon: Holotype (a cranidium), other cranidia and two pygidia are in the collections of the University of Queensland from the *Eugonocare* Stage about four and a half miles north of the Twenty Mile Bore on Glenormiston.

EUGONOCARE PROPINQUUM sp. nov.

(Pl. XXIII, figs. 19, 20.)

Diagnosis : Cranidium indistinguishable from that of *E. tessellatum.*

Free cheeks subtriangular, the genal angles produced into long spines oblique to the general length. The rim is flat and the surface is covered with fine radial wrinkles.

The pygidium is sub-semicircular. The axis has four or five rings that are well impressed. The pleura are convex and on each side have four rounded ribs that extend straight and radially for two-thirds of their length and then rather abruptly contract. The margin is flat and narrow.

Remarks : At a locality a little further north from where the genotype (*E. tessellatum*) was collected another species has been obtained. I can find no features on the cranidium that will allow me to separate the two forms, but the pygidia are different. On *E. tessellatum* the pleural portions of the pygidium are sub-triangular and are bounded by a wide margin. In *E. propinquum* these regions are sub-semicircular and the margin is narrow. Several heads and tails have been found at each locality and these resemblances and differences are constant.

Locality and horizon : From the *Eugonocare* Stage, five miles north of the Twenty Mile Bore, Glenormiston (University of Queensland Collection).

EUGONOCARE SP. INDET.

From the *Glyptagnostus* Stage, about sixteen miles south of Glenormiston homestead, cranidia of *Eugonocare* have been collected. No pygidia have been obtained ; and without these it is not possible to place the form specifically.

Genus ANOMOCARELLA Walcott, 1905.

Genotype : *Anomocarella chinensis* Walcott.

ANOMOCARELLA (?) SP.

(Pl. XXII, fig. 14.)

One cranidium from the *Eurostina* Stage of No. 4 bore, Alroy Downs is figured. It has some affinities with *Anomocarella* but is most likely distinct. It is illustrated for future comparisons. (University of Queensland Collection).

Suborder Ellipsocephalida nov.

Family ELLIPSOCEPHALIDAE Matthew, 1887.

Genus **DINESUS** Etheridge fil., 1896.

Genotype: *Dinesus ida* Etheridge fil.

In 1896 Etheridge founded the genus *Dinesus* on associated cranidia and pygidia from Knowsley in Victoria. Later, in 1903, Gregory gave reason to believe that these were fragments of different genera; and he restricted *Dinesus* to the type of cranidia that Etheridge figured, transferring the pygidia (which he associated with quite different cranidia) to a new genus, *Notasaphus*. Most later authors, including Etheridge, have concurred in Gregory's grouping; and the complete specimens of species of both genera now figured give added testimony to this. A pygidium that more likely is to be regarded as that of *Dinesus ida* (the genotype of *Dinesus*) was figured by Chapman in 1917 (pl. 7, fig. 22) and a complete specimen of *D. ida* from the Templeton Series in Queensland was figured by Kobayashi in 1935.

While the relationship of the fragments of the test was uncertain the affinities of *Dinesus* could not be decided. Walcott's remarks (1905, p. 35; 1913, p. 124), comparing the genus to *Dorypyge*, were based on Etheridge's original interpretation of the fragments.

Gregory (1903, p. 154) who knew only the cranidium, considered *Dinesus* to belong to the Asaphidae. Kobayashi (1935, p. 132) who had a complete specimen, placed it in Dolichometopinae. Complete forms, showing the tiny pygidium, give sufficient evidence that it is not an asaphid; and I find it almost equally difficult to believe that it is a dolichometopid. The features of the cranidium, thorax and pygidium are, however, similar to those of *Ellipsocephalus* and I now suggest placing it in the same family Ellipsocephalidae. *Dinesus* differs from *Ellipsocephalus* in having thoracic spines, basal glabellar lobes and antero-lateral cephalic furrows that connect the axial and anterior furrows. Such features appear independantly in many groups of the trilobites, although it is rare for antero-lateral furrows to be so deeply impressed as they are in *Dinesus*.

Dinesus is present in the early Middle Cambrian beds of Queensland and Victoria. Elsewhere (Whitehouse 1936, p. 73) I have suggested that it is present also in the Siberian Cambrian, being represented by *Solenopleura* (?) *sibirica* (Schmidt) as figured by von Toll (1899, p. 36, pl. 2, figs. 12, 13, 16). Kobayashi (1935, p. 262) included that Siberian species in *Tollaspis*. I do not agree with this; for the features of the cranidium, particularly of the glabellar structures, are very different from those of *Anomocare pawlowski* Schmidt, the genotype of *Tollaspis*. The relatively smooth glabella, the small eyes, the basal lobes, the antero-lateral furrows and the general proportions of *Solenopleura* (?) *sibirica* are all typical of *Dinesus*.

DINESUS IDA (Etheridge fil.)

(Pl. XXIV, figs. 1, 2, 3a, 3b.)

1896 *Dinesus ida* Etheridge Jr., p. 56, pl. 1, figs. 1-4 (non figs. 5 and 6).
1903 *Dinesus ida* Gregory, p. 155, pl. 26, figs. 8-10.
1905 *Dinesus ida* Walcott, p. 35.
1913 *Dinesus ida* Walcott, p. 124.
1917 *Dinesus ida* Chapman, p. 98, pl. 7, figs. 19-22.
1919 *Dinesus ida* Etheridge Jr., p. 381.
1935 *Dinesus ida* Thomas, p. 92.
1935 *Dinesus ida* Kobayashi, p. 134, pl. 22, fig. 3.

A number of complete dorsal shields of a *Dinesus* have been found on the Templeton River in Queensland. Three of these are now figured and Kobayashi has figured a fourth. A certain range of variation is apparent in these forms. Many cranidia of *D. ida* have been found in the Knowsley beds of Victoria and a number of these have been illustrated by Etheridge, Gregory and Chapman. They too show a range of variation, and this range is comparable to that seen in the Queensland cranidia. For that reason I see no advantage, on present evidence, of making a specific distinction. Placing the Queensland species in *D. ida* is in some degree a tentative measure; for although the cranidia agree very well it may be that other portions of the test, if they were known in the Victorian beds, might show some difference. If the small pygidium that Chapman has figured from Knowsley (1917, pl. 7, fig. 22) really belongs to *D. ida* it would indicate such a difference. But this pygidium can be assigned only provisionally to *D. ida*—Conceivably (and I think quite likely) it might belong to some ptychopariid genus.

A specimen (Pl. XXIV, fig. 3a) that is figured from wax squeezes of external moulds shows that axial spines were present on the occipital ring and on each thoracic segment. The other specimens do not show such spines. Presumably they are internal moulds of the test, which thus would appear to have had *solid* axial spines. Figures 3a and 3b on plate XXIV show respectively the dorsal surface[44] and the internal mould of the same individual; and the evidence of spines on the outer surface but not on the internal mould is thereby clearly illustrated.

The specimen shown by plate XXIV, figure 1, has a wider and squarer glabella than the others; but this would appear to be due to a subsequent flattening of the test. The specimen figured on plate XXIV, figs. 3a and 3b, has a perceptibly narrower thorax than the other; but I do not regard it as specifically distinct.

For comparative purposes I have tabulated the dimensions of the five moderately complete specimens as follows. The first entry (1) for each specimen is the overall length of the test in millimetres. The other entries are given as percentages

[44] A wax squeeze of an internal mould.

of this. These are, in order; the length of the cranidium (cl), the width of the cranidium at its base (cb), the width of the cranidium across the eyes (ce), the width of the glabella (gw), the width of the thorax at the fourth segment (tw) and the width of the axis of the fourth thoracic segment (aw).

—	l	cl	cb	ce	gw	tw	aw
Unfigured specimen	24·6	36	55	41	15	60	17
Pl. XXIV—fig. 3	24·6	38	55	37	13	53	17
Pl. XXIV—fig. 2	27·0	37	59	39	14	56	15
Pl. XXIV—fig. 1	28·8	37	58	37	15	57	16
Kobayashi's specimen	28·5	37	59	41	16	58	19

Based on this Queensland material the species may be redefined in the following terms :

The dorsal shield is of an hour-glass shape.

The cephalon is tranversely elongate, the length approximately one half the width. Its margin which is straight across the cranidium and arcuate in the free cheeks has a narrow, raised rim. The maximum width of the cephalon is at the posterior margin. The cranidium is rhomboidal in outline. The glabella is uniformly inflated, has parallel sides and rounded front, and extends almost to the anterior furrow. On it there are a pair of posterior glabellar furrows that unite with the occipital furrow, thus including a pair of narrow basal lobes. No other glabellar furrows are present. There is a small solid median spine on the occipital ring. From the antero-lateral angles of the glabella a pair of short, deep, diverging furrows extend, connecting the axial and anterior furrows. The anterior limb is very narrow. The fixed cheeks are narrow in the anterior and median regions. Palpebral lobes are small (about one quarter the length of the cranidium), centrally situated and have no palpebral ridges. The anterior portions of the facial sutures are subparallel, while the posterior portions slope, fairly uniformly, at an angle of approximately 45° to the length. The free cheeks are relatively wide, are little inflated and have narrow, slightly recurved genal spines that arise rather abruptly from the genal angles.

Restoration.

The thorax is ovate in outline, with its maximum width in the region of the fourth segment. It is not as wide as the cephalon. This ovate outline of the thorax, combined with the relatively great width of the cephalon, gives the curious hour-glass shape to the dorsal shield as a whole. There are eleven segments in the thorax. The axis, in the middle region, is about one third the total width, and it bears on

each segment a small solid spine. The transverse furrows of the axis are wide. The pleura are widely furrowed, the furrows having subparallel sides. They terminate rather abruptly in small and somewhat nodular structures that are continued posteriorly as small spines.

The pygidium is very small, apparently without trace of transverse grooving. The axis is rather more than one-third the whole width and extends to the posterior margin. The pleura are subtriangular and, apparently, smooth.

The hypostome is not yet known.

Only one other species appears to be known—the Siberian form described by von Toll (1899, p. 36, pl. 2, figs. 12, 13 and 16) as ? *Solenopleura sibirica* (Schmidt). This form appears to have very faint glabellar furrows in advance of the basal lobes. Such furrows have not been seen on any of the Australian specimens. Also it has a slightly wider anterior limb on the cranidium and, correlated with this, a slightly convex anterior margin.

Locality and horizon : The species is represented by specimens in the collections of the University of Queensland, the Geological Survey of Queensland and the University of Harvard. They all come from beds of the *Dinesus* Stage of the Middle Cambrian in the Templeton River area, N.W. Queensland.

Genus **ELLIPSOCEPHALUS** Zenker, 1833.

Genotype : *Trilobites hoffi* Schlotheim.

ELLIPSOCEPHALUS (?) **SP.**

(Pl. XXIV, figs. 11, 12.)

Several minute cranidia have been found in the beds of the *Eugonocare* Stage, five miles north of the Twenty Mile Bore on Glenormiston, that may represent the genus *Ellipsocephalus*. However they are so small that, possibly, they are the larval stage of some genus yet to be determined. Two of these cranidia are now figured.

Family PAGODIIDAE Kobayashi, 1935.

Genus **IDAMEA** gen. nov.[45]

Genotype : *Idamea venusta* sp. nov.

Diagnosis : Cranidium rhomboidal in shape, with a smooth glabella that extends to the anterior rim. The sides of the glabella are parallel or very slightly converging. The occipital ring widens at its centre. The fixed cheeks are narrow, convex, with a small palpebral lobe slightly behind the central point. There are no palpebral ridges. The anterior rim is narrow and convex.

[45] I have thought to perpetuate in this way the name of the Idamea tribe of aborigines in whose territory these fossils were collected. Idamea was also the original name of Glenormiston Station. (The pronunciation is Í-dă-mé-ă.)

The pygidium has an axis with several rings, and pleura that are obliquely furrowed. There is a flattened margin to the pygidium.

Remarks: Kobayashi placed in Pagodiidae the five genera *Pagodia* Walcott, *Lisania* Walcott, *Aojia* Resser and Endo, *Hardyia* Walcott and *Pseudolisania* Kobayashi, although for reasons that I find difficult to follow, he thought *Lisania* might be excluded.

Idamea is very similar to *Pagodia*. Indeed my previous references to *Pagodia* (Whitehouse 1930 and 1936) were based on this form. However the fixed cheeks are narrower, the occipital ring widens centrally, and there are no traces of glabellar furrows such as are very faintly impressed on *Pagodia*. *Lisania* and *Aojia* are possibly closer but they have larger eyes. *Pseudolisania* has not the sharply defined anterior rim. *Hardyia*, however, is the genus that most closely resembles *Idamea*. The eyes are slightly more anterior in position in that genus and Walcott mentions the presence of faint glabellar furrows that, however, do not show in his figures. *Idamea* seems to be devoid of glabellar furrows anterior to the occipital furrow.

Certain members of other families occasionally mimic the cranidium of *Idamea*. For instance, *Menocephalites acis* Walcott sp. (1913, p. 175, pl. 16, fig. 11) loses trace of glabellar furrows and so is similar in general form to *Idamea*—but it still retains the characteristic pustulose ornament of its own genus.

Idamea has been found in the *Rhodonaspis* and *Elathriella* Stages of the Queensland Cambrian.

IDAMEA VENUSTA sp. nov.

(Pl. XXIV, figs. 4-6.)

Diagnosis: Cranidium rhomboidal in outline. The glabella is inflated, smooth and converges very slightly until it reaches the anterior rim. The occipital furrow is moderately well incised and behind it the occipital ring widens slowly towards the centre. The fixed cheeks are narrow and convex. The facial sutures converge constantly and fairly evenly towards the front. The palpebral lobes are small, markedly raised from the facial suture posteriorly, and have no continuation as palpebral ridges.

The pygidium has a prominent axis that is rather less than one-fifth the width of the shield. Five or six furrows are impressed on the axis, these furrows becoming crowded in the posterior portion. The pleura, which are fringed by a fairly wide, flat margin, bear three or four simple furrows on each side. The axis reaches to the anterior edge of this marginal zone.

Remarks: Three cranidia and one pygidium have been examined. Associated with them are fragments of free cheeks with long genal spines; but I am far from certain that they belong to this species.

Locality and horizon: From the *Rhodonaspis* Stage of the Upper Cambrian, fourteen miles south of Glenormiston homestead (Geological Survey of Queensland collection).

IDAMEA SUPERSTES sp. nov.

(Pl. XXIV, fig. 7.)

Diagnosis: Cranidium short. The glabella is wide and smooth, with subparallel sides (very slightly converging). The free cheeks are narrow and the palpebral lobes very small. The anterior rim is narrow and convex.

Remarks: Only one cranidium of this form has been found. It is generally similar to *I. venusta*; but the glabella is shorter and wider, with more strictly parallel sides.

Locality and horizon: From the *Elathriella* Stage of the Upper Cambrian at the base of a hill immediately west of Tyson's Bore on Glenormiston (University of Queensland Collection).

Suborder Corynexochida Kobayashi, 1935.

Family CORYNEXOCHIDAE Angelin, 1854.

Subfamily CORYNEXOCHINAE Raymond, 1928.

Genus **CORYNEXOCHUS** Angelin, 1854.

(= *Karlia* Walcott, 1889.)

Genotype: *Corynexochus spinulosus* Angelin.

Much has been written on the genus *Corynexochus* in recent years. Walcott in 1916 revised the genus and published figures of all the forms that, until that time, had been referred to *Corynexochus*. Considerably earlier (in 1889) Walcott had introduced the generic name *Karlia*; but in his revision of 1916 he made *Karlia* a synonym of *Corynexochus*. Notwithstanding this Raymond (in 1928) and Kobayashi (in 1935) have retained *Karlia* as a separate genus. However, the genotypes of the two are so similar that, like Lake (1934), I am satisfied to regard the genera as identical. As a distinguishing feature Raymond noted that the pygidia of the forms referred to *Karlia* had no spines, whereas spines were supposed to be present on the pygidium of *C. spinulosus*, the genotype of *Corynexochus*. But from the observations of Matthew (1899), of Grönwall (1902) and of Lake (1934) it is reasonably certain that pygidial spines are not present on any known form of *Corynexochus* so that this distinction is invalid.

In his review of 1916 Walcott had recognised a subgenus (*Bonnia*) of *Corynexochus*; but recent writers agree in giving this group full generic rank.

The species that in 1916 Walcott placed in the type section of *Corynexochus* included both Lower Cambrian and Middle Cambrian forms. Lake (1934) with good reason removed the Lower Cambrian species but retained all the Middle Cambrian forms with the exception of *C. stephenensis* (Walcott). He included also the Welsh species *C. cambrensis* Nicholas. As a further modification I would suggest removing *C. clavatus* (Walcott) which has quite different palpebral lobes.

By this reading the genus is restricted to Middle Cambrian faunas known only in Scandinavia, Britain, France and Newfoundland—that is, it is a genus of the North Atlantic Province. To this group I now add an Australian species.

In the Northern Hemisphere *Corynexochus* ranges through much of the Middle Cambrian—from the zone of *Hypagnostus parvifrons* to the zone of *Paradoxides forschammeri.* Whether it goes into the zone above (the zone of *Lejopyge laevigatus*) which marks the top of the Middle Cambrian, I am not sure. The Australian form in my opinion (Whitehouse 1936, p. 76) extends the range into the basal zone of the Upper Cambrian. Grabau (1937, p. 378), who postulates a disconformity between the Middle and Upper Cambrian, has suggested that the *Corynexochus* in these beds is " a weathered-out, residual specimen from the Middle Cambrian beds of that region." That cannot be accepted; for not one but a number of specimens of *Corynexochus plumula* have been collected in these beds, and their preservation does not suggest that they are remané fossils.

CORYNEXOCHUS PLUMULA sp. nov.

(Pl. XXIV, figs. 8-10.)

Diagnosis: The cranidium is very convex, composed of three smooth, rounded elements due to the extension of the axial furrows to the anterior margin. Each of these furrows curves in a graceful arc. The glabella expands towards the front, is about twice as long as its maximum (anterior) width, and extends anteriorly beyond the limits of the fixed cheeks. It has a broadly arcuate anterior margin prominently distinct from the lateral furrows. The occipital furrow is well shown but no other furrows are present on the glabella. The occipital ring is highly convex (almost tubercular) and extends posteriorly well below the limits of the cheeks. The fixed cheeks are roughly in the form of isosceles triangles with the height greater than the breadth. At the base the width of each fixed cheek is about the same as that of the glabella. These cheeks are inflated, are quite smooth, and at their lateral margins curve steeply downwards. The posterior marginal furrows are broad and increase

in width towards the sides where they curve forward in sympathy with the posterior lateral portions of the cranidium. The palpebral lobes have slight curvature, are rather widely flattened, contiguous with the glabella and occupy about one half of the lateral margin of the fixed cheeks.

The free cheeks have not been observed ; but from the shape of the margin of the fixed cheeks and the course of the posterior marginal furrow they must have been very small.

The pygidium is relatively large and moderately smooth. The axis extends almost to the posterior margin, is highly inflated and bears three faint furrows. The pleura bend prominently downwards in the marginal area and bear no spines. On each side there are two faint furrows (the posterior furrow hard to discern) that are directed anteriorly from the two anterior axial furrows. A broad, raised anterior rim is present on the pleura, prominent but not sharply limited. The rim has its maximum development about midway along its length.

Remarks : Overseas only five species seem to have been described that may be left in *Corynexochus*. These are *C. bornholmiensis* Grönwall (1902, p. 137, pl. 4, figs. 1, 2) which ranges from the zone of *Hypagnostus parvifrons* to, possibly, the zone of *Paradoxides davidis* in Scandinavia ; the Scandinavian *C. spinulosus* Angelin[46] from the zone of *Paradoxides forschammeri* ; the Welsh *C. cambrensis* Nicholas (1916, p. 464, pl. 39, figs. 4-6) from the zone of *Paradoxides davidis* ; *C. minor* (Walcott)[47] from the *Paradoxides davidis* zone in Newfoundland ; and the French *C. delagei* Miquel (1905, p. 481, pl. 15, fig. 4), of the zonal position of which I am not certain. I have given reason (1916, p. 77) for my belief that the new species *C. plumula* is slightly later in age, representing the zone of *Agnostus pisiformis*.

C. bornholmiensis, the earliest of the forms to appear, has faint glabellar furrows. Such furrows are intensified on *C. spinulosus* and *C. minor*, but disappear from *C. cambrensis* and *C. delagei*. With these latter species it is most apt to compare *C. plumula* since it, too, has a smooth glabella. Both *C. cambrensis* and *C. delagei* are known only from distorted fragments. In both those species, however, the pygidium is clearly different. In *C. cambrensis* the axis and in *C. delagei* both axis and pleura are more deeply furrowed. In both species also the glabella appears to be narrower at the base than it is in *C. plumula*.

Locality and horizon : Five cranidia and three pygidia are in the collections of the University of Queensland from the *Eugonocare* Stage, about four and a half miles north of the Twenty Mile Bore on Glenormiston.

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[46] Angelin, 1854, p. 59, pl. 33, fig. 9 only ; See also Grönwall 1902, p. 139, pl. 4, figs. 3, 4.

[47] See Walcott 1916, p. 324, pl. 36, fig. 7.

Subfamily Dolichometopinae Walcott, 1916.

Genus **AMPHOTON** Lorenz, 1906.

Genotype : *Dolichometopus deois* Walcott.

The name *Amphoton* was proposed by Lorenz (1906, p. 75) for a species that he named *Amphoton steinmanni*. However, in the previous year Walcott (1905, p. 94) had described a species, *Dolichometopus deois*, that, as he pointed out later (1913, p. 216), is identical with Lorenz's genotype. In this latter paper Walcott retained the species in *Dolichometopus* and thus regarded *Amphoton* as a synonym. This procedure later was followed by Sun (1924, p. 81).

Walcott described five species from the Middle Cambrian of China under the name *Dolichometopus*. These are uniformly different from the genotype, *D. svecicus* Angelin (1854, p. 72, pl. 37, fig. 9), in the characters of the pygidium, as Walcott (1916, p. 359) had noted. They form a related group and I agree with Kobayashi (1935, p. 137) that *Amphoton* should be revived as a generic name for it. There can be little doubt, as Walcott points out, that *Dolichometopus deois* Walcott is identical with and has precedence over *Amphoton steinmanni* Lorenz. The genotype thus becomes *Amphoton deois* (Walcott).

In Asia *Amphoton* occurs in the early Middle Cambrian deposits (Mapan Formation) of North China, Manchuria and Chosen and reappears, somewhat later in the Middle Cambrian, in the Taitzu Formation. The genus has a similar, discontinuous range in Queensland. The agreement between early and late species is very close, extending even to microscopic features. For instance Walcott states that *A. alceste* Walcott has a punctate test. Whether or not such a relatively unusual feature as punctation is general for these early forms is unknown ; for some of the known species are not well described. But it is interesting to note that the late species here recorded (*A. serotinum*) is also punctate. It would seem that species of the genus confidently may be expected to be found in intermediate zones of the Middle Cambrian.

AMPHOTON SPINIGERUM sp. nov.

(Pl. XXIV, figs. 13-20.)

Diagnosis : The cranidium is plain. The glabella is long and narrow (length about three times the width), with parallel sides and broadly rounded front. The occipital furrow is well marked. A pair of posterior glabellar furrows are present, extending backwards almost to isolate basal lobes. On some specimens other (anterior) glabellar furrows are faintly indicated on the sides. The neck ring has a median spine. The anterior limb is narrow, flat, and rounded in front and is about

one-sixth the length of the glabella. Fixed cheeks are narrow, the width at the middle of the palpebral lobes being about two thirds the width of the glabella. The palpebral lobes impinge upon the glabella near the anterior end, from which points the facial sutures extend to the frontal margin keeping subparallel. The postero-lateral lobes are long.

The free cheeks are wide, with long genal spines diverging prominently. Thoracic segments have the axis almost equal in width to the pleuron. Long median spines are present on this axis. The pleura have prominent ventral curvature and well marked furrows.

The pygidium is imperfectly known. Its axis has three or four segments, the axial furrows being continued as pleural grooves. The margin is relatively narrow.

The hypostome is elongate, tapering posteriorly, with the extremities prominently rounded. Its anterior lobe is large, occupying about two thirds the total area. The posterior lobe is flat. Anterior wings are very prominent on the hypostome. Maculae are absent.

Remarks: This species, in the features of the cranidium and the thoracic segments, is indistinguishable from the genotype, *A. deois* (Walcott). However the free cheeks and the hypostome that are associated with the genotype are each distinct from those of *A. spinigerum*. The free cheek of *A. deois* has a very blunt genal spine (almost none at all) and the hypostome has not the characteristic anterior wings of *A. spinigerum*. Two other species—*A. dirce* (Walcott) and *A. hyrie* (Walcott)—have long genal spines; but in the general shape of the free cheeks neither agrees quite so closely as does *A. deois*. The cranidial features distinguish still further these two forms.

Endo and Resser (1937, pp. 206-207) have described two other species from the Mapan Formation of Manchukuo—*A. parallela* and *A. alia*. Though similar in many respects neither of these species has a prominent neck spine like *A. spinigerum*.

The specimens are not sufficiently well preserved to determine whether the surface was finely punctate or not.

In the collections of the University of Queensland there are specimens of a crushed form of *Amphoton* from Knowsley in Victoria. They are associated with a species of *Nepea* and come from the horizon called by Thomas (1935, p. 92) the "*Dolichometopus* Band." The species possibly is identical with *A. spinigerum*.

Locality: From the *Amphoton* Stage at "Split Rock" on Waroona Creek, at the crossing of the main road from Camooweal to Mount Isa (University of Queensland Collection).

AMPHOTON SEROTINUM sp. nov.

(Pl. XXIV, figs. 21-23.)

Diagnosis: Cranidium with a long, narrow glabella that expands slightly in the anterior quarter. On it there is a slight tendency to form a keel and there are very faint traces of glabellar furrows. The occipital furrow is shallow and there is a blunt occipital spine. The anterior rim is narrow, slightly curved and of uniform width, and it impinges upon the glabella. The fixed cheeks are narrow with long arcuate palpebral lobes that almost impinge upon the glabella. The posterior lobes of the cranidium are long and extend almost to the genal angles. The free cheeks are wide, rather tumid and have short genal spines.

The pygidium has a prominent raised axis, the posterior lobe of which is markedly elevated. On the axis there are three prominent rings. The pleura are relatively narrow with two pairs of short, rather vaguely defined ribs that end abruptly. The margin is flat with a slight posterior concavity.

The surface is marked by widely spaced microscopic punctations.

Remarks: *Amphoton deois* is the most similar of the early species, but it differs in the absence of genal spines and in the rather more prominent pygidial ribs. *A. alia* Endo and Resser (1937, p. 207, pl. 38, figs. 14-18) is also closely to be compared. It has, apparently, a slightly wider glabella and a more prominent occipital furrow. *A. alceste* Walcott sp. (1913, p. 215, pl. 22, figs. 3a, b) which is similarly punctate has prominent glabellar furrows. Since *A. serotinum* occurs late in the sequence it is interesting to compare it with the late forms in Manchukuo. Endo and Resser (1937, p. 208, pl. 48, figs. 31-33) have recorded one species, *A. divergens*, from the Taitzu formation; but it has a wider glabella than *A. serotinum*. Their other late species, *A.* (?) *subhorrida* Endo and Resser (1937, p. 208, pl. 48, fig. 34), almost certainly is generically distinct. The short nuchal and genal spines of *A. serotinum* distinguish it readily from *A. spinigerum*.

Locality and horizon: From the *Papyriaspis* Stage at a locality a mile and a half west of the road crossing of V Creek, between Undilla and Thorntonia (University of Queensland Collection).

Family ASAPHIDAE Burmeister, 1843.

Genus CHARCHAQIA Troedsson, 1937.

Genotype: *Charchaqia norini* Troedsson.

Charchaqia Troedsson is very similar to *Eoasaphus* Kobayashi 1936 (= *Anorina* Whitehouse 1936[48]). It is perhaps debatable whether the two genera should not be

[48] *Liostracus* (?) *superstes* Linnarsson was independantly chosen by Kobayashi and by myself as genotype respectively of *Eoasaphus* and *Anorina*. Kobayashi's name *Eoasaphus* (March 1936) takes precedence of *Anorina* (April 1936).

merged under the older name *Eoasaphus*. *Eoasaphus superstes* has a faint occipital furrow and light traces of other glabellar furrows, while the glabella has slightly convergent sides. In the species of *Charchaqia* described by Troedsson the sides of the glabella are parallel and the occipital ring merges into the glabella without any trace of an occipital furrow. There are no other notable differences. In other features of the head, and in the details of the thorax and pygidium, there is close agreement. However the differences quoted may be sufficient to allow generic separation. It is unfortunate for such considerations that *Eoasaphus* is known only from one specimen—the holotype of *E. superstes* Linnarsson.

On this division the form now to be described would be placed in *Charchaqia*.

The resemblance to the asaphids, as Kobayashi and Troedsson have noted, is very close and it is probably correct to regard the genera as early members of Asaphidae. However I would call attention to the marked similarity to many dolichometopid genera, for instance *Anoria* Walcott and *Glossopleura* Poulsen. The chief difference is in the number of thoracic pleura—eight in *Eoasaphus* and *Charchaqia* (as in Asaphidae) and seven in Dolichometopinae. Bearing these things in mind it is permissible to suggest that Asaphidae may have arisen from Dolichometopinae. The range in time would allow this. The chief difficulty in such a suggestion, it seems to me, is the systematic position of the early *Ogygopsis* Walcott, a genus that frequently is referred to Asaphidae.

Charchaqia has been recorded hitherto only in the Upper Cambrian of T'ien-Shan. Troedsson has not determined to which part of the Upper Cambrian it should be referred. The related *Eoasaphus* has been found, in Sweden, in the early part of the Upper Cambrian—either the top of the *Olenus* zone or else from the zone of *Orusia lenticularis*.

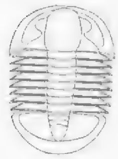
CHARCHAQIA ERUGATA sp. nov.

(Pl. XXV, figs. 6, 7a.)

Diagnosis: Dorsal shield small with parallel sides and with rounded anterior and posterior extremities.

The cranidium is relatively smooth. The glabella is long and inflated, with subparallel sides and rounded front. It is but faintly marked by the occipital furrow. No other furrows are present on the glabella. Although there is a marked difference in convexity between the glabella and the fixed cheeks, the axial furrow is not prominent. The fixed cheeks are narrow. The palpebral lobes are less than half the

length of the glabella, are semicircular in outline and have small posterior impressions, possibly muscle scars. The posterior portion of the facial suture sharply isolates the posterior part of the palpebral lobes and proceeds obliquely to the margin of the head.



Restoration.

There are eight thoracic segments. The axis is about two-thirds the width of a pleuron. The axial rings are smooth and the pleura are widely but shallowly furrowed. These pleura bend rather sharply downwards after about two-thirds of their length.

The pygidium is large, with about six rings discernible on the axis, these rings decreasing in prominence towards the posterior. The axis reaches to the end of the major portion of the pygidium. On the pleural regions only very faint traces of furrows can be discerned. There is a relatively wide, concave margin to the pygidium.

The hypostome and the free cheeks are not yet known.

Remarks: Troedsson (1937) has described three species of *Charchaqia* (*C. norini* T., *C. lata* T. and *C. curvata* T.). Westergaard (1922, pl. 2, fig. 20) has refigured the holotype of *Eoasaphus superstes*. This is the only strictly comparable material. *C. erugata* is a smoother form than any of these. The glabella is unfurrowed (as in the other species of *Charchaqia*) but, because of the faintness of the axial furrow, it merges into the fixed cheeks. The thorax similarly is smoother, and the pygidium has only very faint furrows on the axis and none at all on the pleura.

Locality and horizon: One specimen (the holotype) in the University of Queensland Collection from the *Eugonocare* Stage, about four miles north of the Twenty Mile Bore on Glenormiston Station.

CHARCHAQIA SPP.

Relatively smooth asaphid-like pygidia have been collected at two other localities in Queensland. From the beds of the *Eugonocare* Stage, five miles north of the Twenty Mile Bore on Glenormiston, some small, flat tails were obtained. From other beds, tentatively equated with the same stage, at the mouth of Lily Creek on Chatsworth Station, another species was obtained, larger and more transversely elongated than the others. No pertinent cranidia have yet been found associated. The specimens are in the University of Queensland Collection.

Family DORYPYGIDAE Kobayashi, 1935.

The genera *Bonnia*, *Bonniella*, *Notasaphus*, *Kootenia*, *Olenoides*, *Dorypyge* and *Holteria* form a natural unit. Kobayashi (1935, p. 145) has grouped the last four genera as Dorypyginae, a subfamily of Oryctocephalidae, and has suggested

(p. 131) that *Bonnia* also might be included. Resser (1937, p. 4), in establishing the genus *Bonniella*, also noted the resemblance of *Bonnia* to *Kootenia* and its allies. The group is essentially a Middle Cambrian unit, ranging through the whole of that division ; but *Bonnia*, *Bonniella* and *Kootenia* (*sensu lato*) are members that occur also in the Lower Cambrian.[49] I suggest that the group be given full family status.

Genus **NOTASAPHUS** Gregory, 1903.

Genotype : *Notasaphus fergusoni* Gregory.

In 1896 Etheridge figured certain heads and tails of Cambrian trilobites from Heathcote in Victoria as *Dinesus ida*. Gregory (1903, p. 155) pointed out that these belonged to two different genera, and he proposed the name *Notasaphus fergusoni* for the tails and also for certain other heads that he found in the same bed. Since then the name *Notasaphus* has been used consistently in Australia for such forms.

Notasaphus fergusoni is a very ill-defined species. The specimens from the type locality consist of moulds and casts of isolated cranidia and pygidia, all of them more or less crushed, while more than one species of the genus is present and has been recorded under this name. Also most of the published figures are very poor. Gregory's original figures are crudely drawn outline sketches. Three of his syntypes have been identified in the collections of the Geological Survey of Victoria. The original of plate 26, fig. 13 in Gregory's paper (a tail, here refigured as Plate XXV, fig. 5) is chosen as lectotype.

Two types of pygidia have been figured from the type locality as *Notasaphus fergusoni*. One of these is a relatively long form, with widely spaced ribs. The lectotype, which is of this form, has five spines on each side. Such tails are the commonest in the collections that I have seen. A rather similar form was figured by Etheridge (1895, pl. 1, figs. 5, 6) as *Dinesus ida* and later included by Gregory as *Notasaphus fergusoni*. These specimens, however, probably have six spines on each side. This may be a distinct species ; but a form figured by Chapman (1917, pl. 7, fig. 29) with some rudimentary spines, may serve to link the two. For the present all such types may be regarded as *N. fergusoni*.

Distinct from these is a pygidium figured by Chapman (1917, pl. 7, fig. 28). This is a shorter, broader form, with shorter spines. Chapman's figure shows six spines on each side ; but another specimen of this type in the collection of the Geological Survey of Victoria from the same locality has at least seven on each side. The number probably is variable in the species.

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[49] Chapman (1917, p. 91), in recording *Notasaphus fergusoni* described it as " almost essentially of an Upper Cambrian type "—a statement that appears to be curiously incorrect.

Correspondingly, apparently, there seem to be two types of cranidia. Those figured by Gregory are relatively narrow forms with rectangular glabella. They are the commonest type and no doubt belong to *N. fergusoni* as interpreted above from pygidial data. A specimen of this type is shown in plate XXV, fig. 4.

Chapman (1917, pl. 7, fig. 27) figured a different type of head—a broader form with expanding glabella. I have not seen this specimen or any other like it ; but possibly it is conspecific with the broader tail referred to above.

Interpreting *N. fergusoni* in this way it may be defined as a form with the following features.

The cranidium is approximately equidimensional, with slightly rounded raised rim. The glabella is rectangular, with rounded front, and is marked only by the deep occipital furrow. It extends forwards right to the anterior rim of the head. There is a short, thick occipital spine. The fixed cheeks are smooth and relatively broad with faint, converging, palpebral ridges. The anterior portions of the facial suture appear to be slightly convergent. Palpebral lobes are long. The posterior branches of the facial suture reach the posterior margin of the head at an acute angle.

The pygidium is sub-equidimensional. There are four or five rings on the axis, the last being usually longer than the others. Median spines are not present. The pleura have three stout, rounded and widely spaced ribs, in addition to the raised anterior rim. Beyond these there is a flattened rim that bears four or five recurved spines on each side. The margin, between the two central spines, is sometimes straight, sometimes with rudimentary spines.

The task of framing a definition is made most difficult by the crushed nature of the specimens. Because the specimens are so poor and because of the possibility that several species are represented by such fragments, it is difficult to interpret *Notasaphus* adequately. Until complete dorsal shields are found as topotypes it may be advisable to use the closely related and complete Queensland species, *N. modicus*, for comparative purposes.

In 1889 Walcott[50] erected the genus *Kootenia* basing it on a specimen figured by Rominger (1888, pl. 1, fig. 8) which he named *Bathyuriscus* (*Kootenia*) *dawsoni*. I am not aware that the holotype has since been figured. The name *Kootenia* has been widely used of late notably by Kobayashi (1935) and by Resser (1937). In the sense of such recent usage *Notasaphus fergusoni* falls well within the limits of *Kootenia* ; and recently (Whitehouse 1936, p. 74) I recorded *Notasaphus* as a synonym.

[50] The date of publication of this name usually has been misquoted. It was erected on page 446 of Walcott's paper " Description of New Genera and Species of Fossils from the Middle Cambrian," published in volume 11 of the Proceedings of the United States National Museum. Although this was the volume for 1888 Walcott (1913, p. 13) gives the date of publication as September 3rd, 1889. Vogdes (1925, p. 103) quoted the date as 1888. Kobayashi, on two pages of the same paper (1935, pp. 145 and 146) gives it as 1888 and 1899. Resser (1937, p. 15) stated it to be 1908.

Had not the name *Notasaphus* been proposed I would have been content to leave the species now to be described in *Kootenia*. However, opinions on the morphological limits of genera vary, and it is necessary to enquire whether, on finer delimitations, *Notasaphus* may yet be retained as a valid genus. Certainly among the species at present referred to *Kootenia,* a suite that occurs in both Lower and Middle Cambrian beds, there is marked variation. Glabellar furrows are present on some, absent from others. There is a considerable range in palpebral structures. Axial spines may occur on or be absent from the pygidium. The number of thoracic segments varies, although in most species the thorax has not been described. On the pygidium there is a variation in the number of axial rings, pleural furrows and marginal spines. Such variation conceivably may lead to generic subdivision. Two major groupings may be noted—a series in which axial spines, present on the thorax, are continued on the pygidium and another group in which such pygidial spines do not occur. Within each such group there is considerable variation. For instance, in both sections there are forms with smooth glabella and others that have glabellar furrows. However to make a complete generic analysis of the suite it would be necessary to have access to at least the American specimens.

The genotype of *Kootenia* has axial spines on the pygidium. The genotype of *Notasaphus* has no such spines.[51] The eyes of *Notasaphus* are larger. Furthermore, seven segments are present in the thorax of the genotype of *Kootenia* whereas in *Notasaphus modicus* (the only member of the *Notasaphus* group in which a complete thorax is known) there are eight segments. It is permissible, therefore, to retain *Notasaphus* as a distinct genus.

To what extent it may be independent of the American forms without axial spines on the pygidium—forms with smaller eyes, stronger palpebral ridges and, sometimes, faint glabellar furrows—it would be injudicious to say at present. Perhaps by examining the material, more than one generic unit may be recognised in this assemblage.

NOTASAPHUS MODICUS sp. nov.

(Pl. XXV, figs. 1-3.)

Diagnosis : Dorsal shield regularly oval.

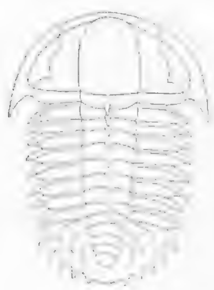
The cephalon is transversely elongate, the width being twice the length. The anterior and lateral margins form a uniform arc. The glabella is wide, with parallel sides and semi-circular front and extends to the anterior rim. On it the only marking is the broad occipital furrow. The occipital ring bears a median spine. The fixed

[51] Care must be taken in determining whether such spines are present or not. An internal mould may not show traces of spines, if these were solid structures.

cheeks are narrow. The facial sutures converge slightly towards the front, are only slightly arcuate in the palpebral lobes, and posteriorly extend outwards and backwards in semicircular curves. The palpebral lobes are continued to the glabella by converging processes that are hardly ridges but really changes in the declivity of the fixed cheeks. The area in front of these processes is depressed ; behind them the cheeks have the normal inflation. The free cheeks are slightly wider than the fixed cheeks and bear prominent genal spines that diverge posteriorly.

The thorax has eight segments. The axis, which is about one third the total width, is simply arched and bears a median spine towards the posterior edge of each segment. The pleura are widely furrowed ; beyond the fulcrum they contract in acute angles and terminate in recurved spines.

The pygidium is slightly shorter than the head. It is semicircular in outline. The axis tapers posteriorly but ends bluntly. Five segments are defined on it by rather broad grooves, the final segment being longer than the others. Four pleural furrows are present on each side, the ribs between them being uniformly convex and not otherwise furrowed. Beyond these ribs there is a narrow, flat margin fringed on each side with five slightly recurved spines with interspaces about twice their own width.



Restoration.

The hypostome consists of an ovate lobe surrounded by a very narrow rim. This rim is concave anteriorly, with small anterior wings. Laterally and posteriorly it is a raised structure. The central, ovate lobe slopes gradually to the posterior rim but descends rather steeply on the sides. Maculae are present on the posterior portion of the lobe. They have well defined margins in the postero-lateral regions ; but anteriorly they merge into the lobe.

Remarks : Two complete dorsal shields (one of an immature individual) and several isolated cranidia, pygidia and hypostomes have been found.

Generally it is very similar to *N. fergusoni,* but the fixed cheeks are rather narrower, the occipital spine more slender and the number of marginal spines on the pygidium is constant. There are five such spines on each side, whereas in *N. fergusoni* the number seems to vary from four to six. Comparison with overseas species is difficult, again by reason of the lack of complete specimens.

Locality and horizon : From the *Dinesus* Stage of Beetle Creek, 12 miles north-west of Mount Isa (University of Queensland Collection).

NOTASAPHUS (?) SP.

Two fragmentary cranidia, belonging to some genus of Dorypygidae have been obtained from the *Eurostina* Stage at No. 4 bore, Alroy Downs.

Family CERATOPYGIDAE Raymond, 1913.

Three genera from the Cambrian of Scandinavia, *Proceratopyge* Wallerius, *Hysterolenus* Moberg and *Ceratopyge* Corda,[52] are so similar that no one has yet questioned their relationship and they have been grouped in the one family. *Proceratopyge* is found in the uppermost zone of the Middle Cambrian and in the three succeeding zones—that is, in the early part of the Upper Cambrian. *Hysterolenus* is a Lower Tremadocian and *Ceratopyge* an Upper Tremadocian genus. All three are known in Scandinavia from dismembered fragments only. They agree well in details of the cranidium and of the pygidium.

The cranidia of these forms have narrow fixed cheeks, small but prominent eye lobes and long posterior limbs. The glabella is long, often with grouped anterior furrows and typically with the posterior pair of furrows isolated and extending more or less parallel with the axis. In the earliest genus (*Proceratopyge*) the glabellar furrows are much less sharply incised than in the later genera.

The pygidia have a pair of prominent spines that arise from fused anterior pleura, these particular pleural portions being markedly distinct from the rest of the tail.

In 1912 Walcott described a species from British Columbia as *Ceratopyge canadensis*. Later (1916, p. 374, pl. 65, fig. 1) he proposed the generic name *Housia* for another cordilleran species, *Dolichometopus* (*Housia*) *varro* Walcott. In 1925 he transferred *Ceratopyge canadensis* to *Housia*. The resemblance of *Housia* to *Proceratopyge* is most marked. The American forms have the same type of pygidial spines, while the cranidium, in *H. canadensis* at least, has the peculiar glabellar furrows of the family. Compared with the genotype of *Proceratopyge* the American species have longer and more concave anterior limbs and narrower fixed cheeks. Unfortunately the genotype is the only Scandinavian species whose cranidium is known, the other species being based on pygidia only. However the cranidia of the species that now are described from Australia show a gradation from forms like the genotype to others that are closely to be compared with the American species. On *P. lata* for instance, like the genotype, the fixed cheeks are relatively wide and the anterior limb is comparatively short, with shallow, diverging furrows. *P. rutellum*, on the other

[52] For good figures of the three genotypes see Westergaard 1922, pl. 2 (*Proceratopyge*), Moberg 1898, pl. 17 (*Hysterolenus*) and Moberg and Segerberg 1906, pls. 4 and 5 (*Hysterolenus* and *Ceratopyge*).

hand, has a longer and a smooth anterior limb as in the American species and, like them, the fixed cheeks are so reduced that the eye lobes practically impinge upon the glabella. *P. nectans* and *P. polita* are intermediate in their characters. The gradation is such that a generic separation is not warranted on cranidial features alone.

I have not handled specimens of the Scandinavian and American forms; but by comparing figures of the pygidia it would seem that on the American species the spinose pleural portions are more markedly distinct from the rest of the tail than they are on the Scandinavian species while, in addition, the posterior border is possibly wider. This latter feature I would not stress; for the Scandinavian *P. nathorsti* Westergaard has a rim as wide as the genotype of *Housia*. The degree of distinction between the spinose and non-spinose pleural regions may be more apparent than real. Most of the published photographs from America have been retouched and these pleural boundaries outlined. Those that seem to be the least retouched (Walcott 1925, pl. 22, figs. 10 and 11) are least suggestive of this sharp distinction. Possibly a direct comparison of the Scandinavian, American and Australian material may show some grounds for separation; but from the evidence that I have at present I find no reason to recognise two genera. The American species, occurring in the Mons and Goodsir Formations, are apparently somewhat later in age than the Scandinavian forms but not, I think, sufficiently later to warrant generic separation purely for such a reason.

In *Proceratopyge* (including *Housia*) the spinose pleura of the pygidium are the anterior members of the tail. In the later genera, *Hysterolenus* and *Ceratopyge*, a non-spinose segment is fused to the pygidium in advance of these. A curious form described by Moberg[53] as *Hysterolenus* (?) *levicauda* has three non-spinose segments in front of the spinose pleura of the pygidium. Unfortunately the cranidium of this form has not been found.

The fusion of a spinose segment on the anterior portion of the pygidium has happened in many families of the trilobites. *Redlichia* has it. So too have some species of *Paradoxides*. Of itself this feature is not of genetic importance. But when to this is added other curious features (in this group the peculiar glabellar furrows on very similar cranidia) we reasonably may combine the genera into a family. Nevertheless Kobayashi (1935, pp. 269-273) recently has placed *Housia* in a very different family, the Marjumiidae.[54] He regards it as having a cranidium and a

[53] Moberg and Segerberg, 1906, p. 84, pl. 4, fig. 40.

[54] I cannot regard *Housia* and *Marjumia* as related genera. All portions of the test, cephalon, thorax and pygidium, are different in the two groups. The pygidum of *Marjumia callas* Walcott (1916, p. 404, pl. 65, fig. 3) is similar to that of *Housia*; but in this way *M. callas* differs markedly from the genotype of *Marjumia* (*M. typa*, Walcott sp.).

pygidium very different from typical Ceratopygidae. I fail to see this difference in cranidia. As I have already indicated, the Australian forms provide a link between the two. Also Kobayashi's remarks about the pygidia are, I venture to suggest, not in accord with the facts. According to him the spines in *Housia* arise from the anterior pygidial segment but in Ceratopygidae (and he includes *Proceratopyge*) they are on the second segment. Certainly in *Hysterolenus* and *Ceratopyge* they are on the second segment; but in *Proceratopyge* they occupy the same anterior position as they do on *Housia*.

Kobayashi (1935, p. 293) added a Middle Cambrian genus, *Kogenium*, to the family. This has a tail similar to *Proceratopyge*; but the cranidium has wider, fixed cheeks and a rather different anterior rim. Nevertheless there is, on its glabella, a sharp recurvature of the furrows that may be an incipient development of the curious furrows of *Ceratopyge*; and for this reason the genus may be retained as an early member of the family.

Recently Troedsson (1937, pp. 35 and 39) allotted two new Asiatic genera, *Lopnorites* and *Diceratopyge* to the family. In the latter genus the glabella is smooth; but *Lopnorites* has isolated posterior glabellar lobes comparable with those of other members of the family. In his review Troedsson proposed making two subfamilies—Hysteroleninae (to include *Kogenium* (?), *Lopnorites* and *Hysterolenus*) and Ceratopyginae (for *Proceratopyge*, *Diceratopyge*, and *Ceratopyge*). The distinction was based on eye lines present in the first group but absent from the second, and the greater segmentation of the pygidium in Hysteroleninae.

The distinction seems to me to be poorly founded. As Troedsson pointed out, in some species of *Proceratopyge* the pygidium is quite well segmented. Furthermore, *Ceratopyge latelimbata* Moberg and Segerberg (1906, p. 87, pl. 5, fig. 6), occurring in the same bed as the genotype and a typical member of *Ceratopyge*, has quite definite eye lines. I prefer, therefore, not to use the division.

Of these six genera three only (*Proceratopyge*, *Lopnorites* and *Diceratopyge*) are known from complete dorsal shields. *Kogenium* is the first genus to appear (relatively early in the Middle Cambrian) followed by *Proceratopyge*. *Lopnorites* and *Diceratopyge*, possibly contemporaneous genera, are the next to arrive, followed by *Hysterolenus* and then, closing the sequence, *Ceratopyge*.

From *Kogenium* to *Proceratopyge* the main change is in the reduction of the free cheeks. This change continues during the range of *Proceratopyge*. The first species to appear (*P. conifrons*) has the widest cheeks; but in *P. rutellum*, *P. varro* and *P. canadensis* the reduction of the fixed cheeks reaches the acme for the family.

The later genera show other changes. In *Lopnorites* the number of thoracic segments is reduced to nine (there are ten in *Proceratopyge*, as shown on *P. canadensis*) and eye lines appear. The glabella retains the characteristic furrows. The pygidium is in some species but moderately segmented, in others highly furrowed. *Diceratopyge* differs in quite other ways. It adds to its pygidium, which is most poorly furrowed, a wide zone (possibly composed of more than one fused segment) in front of the spinose member, while the number of thoracic segments is reduced to six. Also, following the mode of certain species of *Proceratopyge*, the glabella becomes smooth. *Hysterolenus* retains the early form of pygidium, with spines on the anterior part, and has no eye lines. In *Ceratopyge* eye lines are sometimes present, sometimes absent, and once more the pygidium has a non-spinose anterior member. In this genus, in contrast to all the others, the glabella widens anteriorly.

Thus instead of seeing two well-defined sections in the family, as Troedsson did, I interpret the evidence as showing a progressively developing group in which the several changes (furrowing of the pygidium, the addition of a non-spinose anterior zone on the pygidium, the smoothing of the glabella and the development of eye lines, for instance) have operated on more than one occasion, producing a plexus of forms from which it is difficult to make sub-groups.

It is interesting to note that each of the species of which complete specimens are known has rather bluntly terminated thoracic pleura. This may explain why, when anterior additions are made to the pygidium, they are non-spinose. Also, correlated with such additions to the pygidium, may be the reduction in the number of thoracic segments—markedly in *Diceratopyge* in which the pygidium has a very wide anterior non-spinose zone and there are but six thoracic segments.

Genus **PROCERATOPYGE** Wallerius, 1895.

(= *Housia* Walcott, 1916)

Genotype : *Proceratopyge conifrons* Wallerius.

PROCERATOPYGE LATA sp. nov.

(Pl. XXV, figs. 12 and 13 (?).)

Diagnosis : Cranidium narrow. The glabella narrows anteriorly with straight sides and rounded front. It is distinct from the free cheeks by a sharp change in the inflation of the test rather than by the presence of limiting furrows. On the glabella, anterior to the shallow occipital furrow, there are three extremely faint pairs of short furrows. The two anterior pairs extend approximately at right angles to the axis, whereas the posterior pair are aligned more or less parallel to it. Actually they

are little more than shallow depressions. These furrows are difficult to see except in oblique light. The fixed cheeks are narrow, their width at the eye lobes being a little more than half the width of the glabella. The palpebral lobes are very small, centrally situated and they project prominently from the edges of the free-cheeks. They are connected to the anterior lobe of the glabella by very faint, converging palpebral ridges. The anterior portions of the facial suture are for the most part parallel, but they converge slightly towards the anterior margin. The posterior portions of the facial suture extend sub-parallel to the posterior margin of the cephalon, thus developing long posterior lobes to the fixed cheeks. The anterior limb is about one-fifth the length of the cranidium and is concave. Diverging from the antero-lateral region of the glabella are two areas slightly more concave than the rest of the anterior limb.

Remarks : At the only locality from which I have obtained this species it is represented by numerous cranidia. In the same rock specimens the cranidia of *P. rutellum* are equally abundant. However only one type of pygidium has been found. These tails, too, are numerous. Cranidia of *P. rutellum* are found at another locality from which I have not obtained *P. lata*, and there they occur with the same types of tail. For that reason I have associated this pygidium with *P. rutellum* ; but I have been tempted to think that, because of the abundant specimens, *P. rutellum* and *P. lata* may have had pygidia of similar type. It may be mentioned that of the only other Australian form whose pygidium is known, *P. nectans*, the tail differs only slightly from this type.

In its cranial features *P. lata* is very similar to the genotype *P. conifrons* Wallerius. The glabella is conical. There are similar glabellar furrows, an anterior limb of comparable length with similar divergent grooves, and the fixed cheeks are of much the same width and general type. Our form may be distinguished by the straighter lines of the anterior facial suture, by the eye being situated rather more to the rear and by the flatter form of the anterior limb.

Locality and horizon : From the *Eugonocare* Stage, five miles north of the Twenty Mile Bore, Glenormiston (University of Queensland Collection).

PROCERATOPYGE NECTANS sp. nov.

(Pl. XXV, figs. 8a, b.)

Diagnosis : Cranidium axially elongate. The glabella narrows anteriorly with straight sides and rounded front. On it the furrows are most faintly impressed. The posterior pair are long and slope backwards towards the axis. The fixed cheeks are relatively narrow. The palpebral lobes are situated opposite the centre of the

glabella and are continued by faint, converging, palpebral ridges. The facial sutures diverge slightly before the eye. The anterior limb is of moderate length and is flat to slightly concave. Faint diverging furrows extend on it from the anterior end of the glabella.

The pygidium is transversely elongate. The axis has four segments, the posterior being considerably larger than the others. From the anterior segment the spinose pleural portions radiate, increasing laterally and ending in long spines roughly parallel with the axis. The remainder of the pleural region has two extremely faint and narrow furrows on each side. The posterior margin is smooth, wide and slightly concave.

Remarks: *P. nectans* is intermediate in its cranidial characters between *P. lata* and *P. rutellum.* The anterior limb and the fixed cheeks are intermediate in size. As on *P. lata* and *P. conifrons* there are faint divergent furrows on the anterior limb. Such furrows are not seen on *P. rutellum* or on the American species. The eye lobes come close to the glabella, but they do not impinge upon it as they do in *P. rutellum.*

Locality and horizon: From the *Glyptagnostus* Stage 16 miles south of Glenormiston homestead (University of Queensland Collection).

PROCERATOPYGE RUTELLUM sp. nov.

(Pl. XXV, figs. 9-11 and 13 (?).)

Diagnosis: Cranidium axially elongate. The glabella narrows very slightly anteriorly with straight sides and rounded front. The glabellar furrows are particularly faint. Two pairs of discontinuous anterior furrows can be seen and a posterior pair that slope backwards towards the axis. The change from the glabella to the fixed cheeks is not well marked. The fixed cheeks are very much reduced. The facial sutures diverge slightly towards the front and impinge upon the glabella at the front of the palpebral lobe. This lobe, situated opposite the centre of the glabella, has the appearance of projecting from it. The posterior lobes of the cranidium are long. The anterior limb is wide and concave and is succeeded by a convex, subtriangular anterior rim that gives an obtusely angular front to the head.

The pygidium is transversely elongate. There are five segments on the axis separated by shallow furrows. The anterior pleural portions extend outwards from the first axial segment, increasing laterally to a triangular shape. These portions are not furrowed and they end in strong spines that are almost parallel to the axis.

The remainder of the pleura have faint furrows extending outwards from the axial furrows. A concave rim borders the pygidium behind the spinose segments. This is of moderate width and is truncated posteriorly.

Remarks : In its cranidium *P. rutellum* is very like the American species *P. varro* and *P. canadensis*. Like them the anterior limb is long and concave, without the faint diverging furrows that are present on the genotype. Also, like those two species, the fixed cheeks are reduced to a minimum, the palpebral lobes impinging upon the glabella. The pygidium of *P. rutellum* is quite like that of *P. nathorsti* Westergaard (1922, p. 120, pl. 2, figs. 3-5) ; but its axis terminates more bluntly and it has a truncated posterior margin that is not present on *P. nathorsti*.

Localities and horizon : From the *Eugonocare* Stage at distances of approximately $4\frac{1}{2}$ miles and 5 miles north of the Twenty Mile Bore, Glenormiston (University of Queensland Collection).

PROCERATOPYGE POLITA sp. nov.

(Pl. XXV, fig. 14.)

Diagnosis : Cranidium axially elongate. The glabella is long, with sub-parallel sides and semicircular front. The occipital furrow is well marked but there are no other grooves on the glabella. The occipital ring is plain and of constant width. The facial sutures diverge slightly in their anterior portions. At the front of the eye lobes they closely approach but do not impinge upon the glabella. The palpebral lobes are situated in the posterior part of the fixed cheeks. The anterior limb is wide and concave and there is no raised rim before it.

The other portions of the test are not yet known.

Remarks : This species is distinguished by its unfurrowed glabella and by the eyes being set a little more to the rear than in most other species. *P. varro* (Walcott) may be another species with a smooth though narrowing glabella. Walcott makes no comment on this matter. But his figures show no glabellar furrows. *P. polita* resembles in many ways *P. rutellum* in which, however, the sides of the glabella converge slightly, the anterior limb is longer and the fixed cheeks are somewhat narrower.

Locality and horizon : From the *Rhodonaspis* Stage at the western base of " Polly's Lookout," Glenormiston. (University of Queensland Collection.)

Family ORYCTOCEPHALIDAE Beecher, 1897 (emend. Raymond, 1913).[55]

Subfamily Oryctocephalinae Kobayashi, 1935.[55]

Genus **ORYCTOCEPHALUS** Walcott, 1886.

Genotype : *Oryctocephalus primus* Walcott.

ORYCTOCEPHALUS DISCUS sp. nov.

(Pl. XXV, fig. 15.)

Diagnosis : Cranidium roughly semi-circular in outline. The glabella is wide with a sub-ovate outline, and extends to the anterior rim. It is marked by the occipital furrow and four pairs of narrow, discontinuous furrows that reach neither the centre nor the sides of the glabella. These furrows decrease in intensity towards the front, the anterior pair being very far forward, very faint and are most nearly at the margins. The fixed cheeks are relatively narrow. The palpebral lobes have convex margins, are regularly arcuate, and are continued in the same arcs by palpebral ridges of similar width. These palpebral ridges meet the glabella near the anterior end, close to the anterior glabellar furrows. The palpebral lobes extend backwards for a considerable distance so that the posterior sections of the facial sutures are very short. The anterior sections of the facial sutures are also short and converge slightly. The pre-palpebral regions of the fixed cheeks are thus small.

Remarks : I have seen only one specimen, a cranidium.[56]

The width and the shape of the glabella, and also the form of the pre-palpebral portions of the fixed cheeks are features whereby the species differs from other known members of the genus.

Oryctocephalus has been described from Middle Cambrian beds in British Columbia, Nevada, Idaho, Chosen and India (Spiti). The genotype, *O. primus* Walcott (1886, p. 210, pl. 29, fig. 3) from Nevada, and *O. reynoldsi* Reed (1899, p. 359) from British Columbia are perhaps the most similar forms. In the course of the facial sutures and the palpebral structures they are closely to be compared, but the

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[55] Actually Beecher's original name was Oryctocephalinae, for he interpreted the group (in a wide sense) as a subfamily of Olenidae. Raymond (1913) defined the family in its present generally accepted limits and, using the termination "-idae," credited the name to Beecher. Kobayashi (1935) subdivided the family into Oryctocephalinae and Dorypyginae, a division that I have followed. In so doing Kobayashi credited the family name (Oryctocephalidae) to Raymond who first used it and the subfamily name (Orcytocephalinae) to Beecher. Etymologically this is of course correct. But the usage that I have adopted here expresses more adequately the growth of ideas about the family.

[56] Dr. W. E. Schevill informs me that he collected *Oryctocephalus* from the beds of the Templeton Series and that these specimens (which I have not seen) are in the collections of Harvard University. It is probably to these specimens that Kobayashi (1934, p. 296) has referred when recording *Oryctocephalus* from the Templeton River.

outlines of the glabellae are different. In *O. primus* the sides are parallel. In *O. reynoldsi* the glabella slowly expands—more slowly than does *O. discus*. The Indian *O. salteri* Reed (1910, p. 11, pl. 1, figs. 16-21) and the Korean *O. orientalis* Saito (1934, p. 230, pl. 25, figs. 17-22) and *O. Kobayashii* Saito (1934, p. 231, pl. 25, figs. 23-25) have deeper pits on the cranidium. Also the glabella in the two latter species does not expand. In *O. salteri* the glabella is most comparable in outline to that of *O. discus*.

Locality and horizon: Holotype from the *Dinesus* Stage of the Templeton River (University of Queensland collection). I understand that specimens of a species of *Oryctocephalus* from these beds are in the Harvard University Collections (see footnote 56, p. 252).

4. SUPPLEMENT No. 1.

(A) Explanation.

While this series of papers is being issued field work in the area is progressing intermittently; and so I have thought it advisable to attach to each new part that is published a supplement—to record additions to groups that previously have been illustrated and new facts about the stratigraphy of the Cambrian in this region. Part I of this series was a stratigraphical outline. The correlations that I made then with areas elsewhere in Australia and provinces overseas were stated very briefly. No more was possible, for most of the evidence had yet to be presented. As in each succeeding part more of this evidence appears reasons can be given more fully for the correlations that have been made; and in the light of new discoveries such correlations can be criticised and reviewed. These things I propose to do in the supplements.

(B) Some New Records of Agnostids.

Some new agnostid trilobites have been found since Part 2 of this series of papers was printed.

Family AGNOSTIDAE McCoy, 1849.

I have already discussed the limits of this family (1936, p. 84). Within it two groups may be recognised—the genera *Agnostus*, *Euagnostus*, *Solenagnostus*, *Fallagnostus* and *Ceratagnostus* have simple glabellae; but on *Goniagnostus*, *Triplagnostus* and frequently on *Homagnostus* the posterior glabellar lobe has a pair of notches. This feature is retained in the family Pseudagnostidae which possibly arose from *Homagnostus*. However I do not think it wise to make a subfamily division in Agnostidae on this feature; for on some species of *Agnostus*, for instance

A. hedini Troedsson (1937, p. 20, pl. 1, figs. 6-8) and *A. intermedius* Tullberg (1880, p. 17, pl. 1, figs. 4a, b), faint depressions occur in positions corresponding to the glabellar notches of *Goniagnostus*, while notches are sometimes present, sometimes absent on *Homagnostus*.

Genus **AGNOSTUS** Brongniart, 1822.

= *Battus* Dalman, 1826.)

Genotype : *Entomolithus paradoxus pisiformis* Linnaeus.

In describing *Agnostus seminula* I have pointed out that it belongs to a group of many species, differing from the genotype and its immediate relatives, in having a narrower axis and no pygidial spines. Also it occurs earlier than the type section. If later researches show that this stratigraphical distinction is constant it may be advisable, eventually, to separate this group subgenerically.

AGNOSTUS SEMINULA sp. nov.

(Pl. XXV, fig. 24.)

Diagnosis : Relatively a narrow form, only slightly inflated. The facets at the base of the cephalon and the front of the pygidium are well developed.

The cephalon narrows slightly towards the front and has a very narrow uniform rim. The axial furrows are well incised while the other cephalic furrows are less prominent. The glabella is very narrow, extending forwards for about three quarters the length of the head and occupying about one quarter of the total width. The anterior lobe is one third the length of the glabella. The posterior lobe has parallel sides. Accessory lobes are narrow.

The two thoracic segments are of the usual types with tuberculate axis and short inflated pleura.

The pygidium has a non-spinose rim that is wider than the cephalic rim and widens slightly but progressively to the posterior. The axis is wider than that of the cephalon. The margins of the anterior segment converge anteriorly. Posterior to this the axis widens very slightly towards the centre and then tapers to a point close to the rim. The anterior segment is very narrow, limited posteriorly by a prominent furrow. The median segment has a tubercle that increases in prominence posteriorly. Between the median and posterior segments the furrow is moderately incised, extending posteriorly in the centre to bound the median tubercle. Pleura are continuous in the narrow space behind the axis.

Remarks : *A. seminula* is easily distinguished from the genotype, *A. pisiformis* Linnaeus sp. (see Tullberg, 1880, pl. 2, figs. 14a, b), and from the Canadian form described by Matthew as *A. pisiformis* var. These are plump forms with wider axes, wider accessory lobes and, also, with pygidial spines. The Asiatic *A. hedini* Troedsson (1937, p. 20, pl. 1, figs. 6-8) and the arctic *A. pater* Holm and Westergaard (1930, p. 9, pl. 1, fig. 1, pl. 4, figs. 9, 10) belong to the group of *A. pisiformis* and also are markedly distinct from *A. seminula*. There is, however, a series of flatter forms with narrower axes and no pygidial spines with which it should be compared. *A. intermedius* Tullberg (1880, p. 17, pl. 1, figs. 4a, b) is of this type. It has a more acuminate glabella and has pleural furrows on the head. A specimen figured by Illing (1915, p. 408, pl. 28, figs. 11, 12) from the Stockingford Shales as *A.* cf. *intermedius* is more akin to this species and may even be identical. However some of the pertinent detail is not shown on Illing's specimen. The Welsh *A. typicalis* Nicholas (1915, p. 454, pl. 39, fig. 2) is very similar, particularly in the glabellar features. However on the pygidium the axis is rather shorter and the second transverse axial furrow is not so much deflected in the centre. *A. acutilobus* Matthew (1886, p. 73, pl. 7, fig. 10) from Canada also is most closely allied. It is a narrower form and, as in *A. typicalis*, the second axial furrow on the pygidium is straighter. These four species that closely may be compared with *A. seminula* all occur in the zone of *Paradoxides hicksi*. The plumper forms with wider axes and pygidial spines seem everywhere to be slightly later in age.

Locality and horizon : From limestones in the *Agnostus seminula* Stage, eleven and a half miles north east of Yelvertoft Dip, on the road to the Paradice Goldfield (University of Queensland Collection).

Genus **CERATAGNOSTUS** gen. nov.[57]

Genotype : *Ceratagnostus magister* sp. nov.

Diagnosis : Forms with the cephalon of the same type as *Agnostus*. The pygidium has a bispinose rim, a post-axial furrow and an axis that is prominently constricted, laterally and vertically, at its posterior end. The posterior transverse furrow has been effaced from the pygidial axis, and the anterior furrow is either very faint or absent.

Remarks : There is a group of Middle Cambrian species, in the zone of *Paradoxides davidis*, with the above features. *C. magister* sp. nov. from Australia and *C. incertus* (Brögger) from Europe are of this type, while Howell records *Agnostus* cf. *incertus* from Canada. Since it is an easily recognised group, widely distributed and of limited stratigraphical range, even though it is separated by only small differences from some other agnostids, I have thought it advisable to give it a generic

[57] In reference to the horn-like form (κέρας a horn) of the pygidial axis.

name. Defined in this way *Ceratagnostus* is similar to *Solenagnostus* on the one hand (differing in the constricted termination and the rudimentary furrows of the pygidial axis) to *Euagnostus* (which has a more regular pygidial axis) and to *Goniagnostus* (from which it differs in the absence of glabellar notches and pleural furrows). As noted below (p. 257) the genus possibly arises from the group of *Euagnostus* (?) *exaratus* Grönwall.

CERATAGNOSTUS MAGISTER sp. nov.

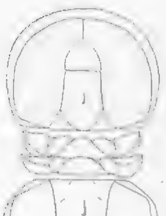
(Pl. XXV, fig. 27.)

Diagnosis : Relatively a very large form, the average length of specimen being 13 mm. Facets on both cephalon and pygidium are prominently shown.

The cephalon is moderately inflated, subcircular in outline and has a uniform, slightly elevated rim. Circumaxial and glabellar furrows are deeply incised, while the pre-glabellar furrow is less sharply marked. The glabella is subovate. Its length is about three quarters of the total length of the cephalon while its width is about one quarter. The anterior lobe is subtriangular with convex sides. The posterior lobe tapers very slightly towards the front and has a strongly rounded base. Accessory lobes are very well marked, triangular in outline and are confluent behind the posterior lobe on the deflected posterior slope of the head. There is a small, very faintly developed tubercle in the centre of the posterior lobe.

The two thoracic segments have strongly tuberculate axes and normal, short, bulbous pleura, these " bulbs " being adjacent to the head and the tail.

The pygidium is subcircular with a uniform, inflated rim that has a pair of prominent postero-lateral spines. As on the head, the rim extends to the axis, thus accentuating the facets. Posteriorly the axis decreases to the first transverse furrow after which it remains fairly constant in width to about the centre of the tail, beyond which it rapidly tapers to a point. The tapering portion is considerably less inflated than the rest of this axis. On the axes the first transverse furrow is faintly incised, but the second furrow has practically disappeared, only a very slight depression being left. The median tubercle is not prominently defined.



Restoration.
(x. 3)

Remarks : *C. magister* is very similar to *C. incertus* Brögger sp. (as figured by Tullberg, 1880, pl. 1, figs. 6a, b), differing in the larger sizes (it is about 50% larger in linear dimensions) and by the slightly more obtuse termination to the axis of the pygidium. As *Agnostus incertus* Lake (1907, p. 29, pl. III, figs. 1-3) has figured some Shropshire forms that may represent another species of the genus. Lake has called attention to certain

differences in the cephalon; while his figures seem to indicate a pygidial axis of slightly different shape and that the marginal spines on the pygidium are closer together. The tail figured by Illing (1916, p. 407, pl. XXVIII, fig. 10) as *Agnostus* cf. *incertus* is badly preserved; but in size it is comparable with *C. magister.* It is of interest to note that Illing (1916, p. 406) records *Agnostus exaratus* var. *tenuis* Illing through a considerable range of beds. The last members of this lineage, in the zone of *Paradoxides davidis*, develop a constricted end to the pygidial axis and he regards them as a definite mutation. These late members may be placed in *Ceratagnostus* and suggest that the group of *Euagnostus* (?) *exaratus* Grönwall is the ancestor of the genus.

Locality and horizon: From the *Papyriaspis* Stage at the road crossing of V Creek, between Undilla and Thorntonia. Also from the *Phoidagnostus* Stage a mile and a-half west of that locality (University of Queensland Collection).

Genus **GONIAGNOSTUS** Howell, 1935.

Genotype: *Agnostus nathorsti* Brögger.

It is not clear, at the moment, if *Goniagnostus* Howell and *Triplagnostus* Howell should be regarded as distinct genera. The names were proposed in the same paper; and although Howell gave long diagnoses, these were identical in phrasing until the closing sentences when, for distinctions, it was noted that *Goniagnostus* had pleural furrows on the head and pygidial spines, while *Triplagnostus* had smooth cheeks and no spines. But there are forms in this group, such as *Agnostus atavus* Tullberg (1880, p. 14, pl. 1, fig. 1), that have deep pleural furrows but no spines, and others, for example *G. purus* sp. nov., with pygidial spines but no pleural furrows.

If the genera are to be kept distinct then apparently the only criterion for separation is the presence of pygidial spines on *Goniagnostus* but not on *Triplagnostus*. Occasionally in other groups of agnostids such a distinction, small though it is, is valid. In Pseudagnostidae, for instance, pygidial spines are the only morphological features discriminating between *Pseudagnostus* and *Plethagnostus*. There the position is clear since the one genus (without spines) occurs slightly later than the other. Similarly, as I have already noted, it may be considered advisable in the future, to make a division within *Agnostus* (*sensu stricto*) since the non-spinose species appear all to be earlier than those with spines. But in the present group there is no such

stratigraphical distinction. Typical goniagnostids and triplagnostids commonly occur together. That in itself, of course, does not preclude separate generic entity. Howell (1935, p. 109) states that *Triplagnostus* ranges throughout most of the Middle Cambrian while *Goniagnostus* occurs merely in the zones of *Paradoxides hicksi* and *P. davidis* in the Middle Cambrian. *Goniagnostus* could thus be an offshoot of more limited vertical range, arising early from *Triplagnostus* and developing spines. This is indicated by the intermediate position of *G. purus*, described below.

Since the two names have been proposed it probably will reduce confusion if both are employed, until such time as an adequate revision can be made of all species in the group. If, eventually, only one name is to be recognised *Goniagnostus* has one page precedence over *Triplagnostus* and, in the absence of other reasons for choice, should be used.

GONIAGNOSTUS PURUS sp. nov.

(Pl. XXV, figs. 21-23.)

Diagnosis : The cephalon is subcircular with a narrow rim. The glabella tapers uniformly to the front. The axial, pre-glabellar and anterior glabellar furrows are all narrow but sharply defined. The anterior glabellar lobe is about one third of the length of the glabella. On the posterior glabellar lobe the paired notches are small but distinct. Accessory lobes are narrow and acutely triangular. The glabellar tubercle is small, sub-circular, and situated towards the rear of the posterior lobe. Usually the pleura are smooth ; but one form has been found with faint long and short radial furrows developed only near the rim.

The pygidium is subrectangular, the width slightly greater than the length. Apparently it is slightly more inflated than the cephalon. The rim is fairly uniform in width and bears two small postero-lateral spines. The axis is much inflated, has subparallel sides in its median region and terminates bluntly. It is rather more than two-thirds the total length of the pygidium. The two axial furrows are well impressed. The median tubercle is prominent, on the posterior portion of the centre segment.

Remarks : No complete specimen of conjoined cephalon, thorax and pygidium has been obtained. In the limestone from which the material was gathered heads and tails, each of two types, occur abundantly. One such head and tail were conjoined and have been described above (*Agnostus seminula*). The other type of head and the other type of tail are thus figured here confidently as the one species.

G. purus is a curious species. Although it has the marginal spines of a *Goniagnostus* it is most similar among described forms, to *Agnostus gibbus* Linarsson the genotype of *Triplagnostus,* which species already has been recorded from Queensland (Whitehouse 1936, p. 84, pl. 8, figs. 6, 7) apparently from a slightly lower horizon (*Dinesus* Stage). But for its spines it is hardly to be distinguished from that species. In the blunt ending of the pygidial axis and in the smoothness of the cephalic cheeks it also suggests *Triplagnostus* more than *Goniagnostus.* Only one specimen has shown any trace of the radial furrows on the cheeks of the cephalon, and on that they are faint and restricted to the outer edge.

Howell (1935, p. 14) states that *Goniagnostus* begins in the zone of *Paradoxides hicksi.* The only other species that occurs with *G. purus* is *Agnostus seminula* Whitehouse, a member of a subdivision of *Agnostus* that is known only in the zone of *Paradoxides hicksi.* These things suggest that *G. purus* is a very early member of *Goniagnostus,* having recently branched off from the group of *Triplagnostus gibbus* and not yet acquired all the typical features of a *Goniagnostus.*

Locality and horizon : From the *Agnostus seminula* Stage in limestones eleven and a half miles north of Yelvertoft Dip (Holotype in the University of Queensland Collection. Other specimens in this and in the collection of the Geological Survey of Queensland).

GONIAGNOSTUS cf. **NATHORSTI** (Brögger).

(Pl. XXV, fig. 20.)

1878. *Agnostus nathorsti* Brögger, p. 68, pl. 5, fig. 1.
1880. *Agnostus nathorsti* Tullberg, p. 21, pl. 1, fig. 9.
1935. *Goniagnostus nathorsti* Howell, p. 14, pl. 1, figs. 1, 2.

Two Queensland specimens appear to be identical with this species, the genotype of *Goniagnostus.* They agree particularly well with the figures of topotypes recently published by Howell. They have the same shape, similar regularly tapering glabella, radial cephalic furrows of the same type and small pygidial spines. By comparing figures (I have seen no topotypes) I can find no essential difference between the Queensland and the Scandinavian forms.

In Scandinavia the species occurs in the zones of *Paradoxides davidis* and *Paradoxides forschammeri.*

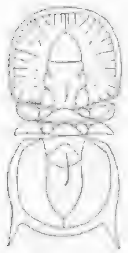
Locality and horizon : From the *Papyriaspis* Stage on the road from Undilla to Thorntonia, a mile and a-half west of V Creek (University of Queensland Collection).

GONIAGNOSTUS SCARABAEUS sp. nov.

(Pl. XXV, fig. 19.)

Diagnosis : Relatively a large form (10 mm. long) with straight, parallel sides.

The cephalon is subquadrangular, about two-thirds the total length and one-third the width. The posterior lobe has subparallel sides and the anterior lobe is triangular. The pair of median notches on the posterior lobe are deep and long. Accessory lobes are subovate, constricting the base of the posterior lobe. Axial, glabellar and pre-glabellar furrows are prominent. The cheeks are marked with radial furrows in an inner and an outer zone. In the inner zone there are three or four pits on each side of the posterior glabellar lobe and one on each side of the anterior lobe. In the outer zone, on each side, there are five furrows, progressively increasing in size anteriorly to the mid region of the head. Anterior to this the furrows are alternately long and short.



Restoration.
(x. 3)

The thorax consists of two segments with tuberculate axis and short bulbous pleura, the bulbs being on opposite sides of the pleura—adjacent to the margins of the head and tail.

The pygidium is subquadrangular with well developed facets. There is a narrow rim that generally remains constant in width ; but at the postero-lateral angles spines arise that continue the straight line of the sides. The axis is long, narrow and acuminate, extending almost to the rim. Anteriorly its margins diverge but slightly. The transverse furrows diverge from one another in the centre around a tubercle.

Remarks : With its long pygidial spines, the radial cephalic furrows developed in two zones and, to some extent, the parallel sides of the test, this species is sufficiently distinct from all described forms. Perhaps the genotype, *G. nathorsti*, is the most similar form.

Locality and horizon : One specimen has been found in beds of the *Papyriaspis* Stage at the road crossing of V Creek between Undilla and Thorntonia (University of Queensland Collection).

Genus **EUAGNOSTUS** Whitehouse, 1936.

EUAGNOSTUS SP.

One pygidium of a *Euagnostus* (in the University of Queensland Collection) has been found in the *Papyriaspis* Stage at the road crossing of V Creek, between Undilla and Thorntonia. It is a plump, thick-shelled form like *Euagnostus opimus* Whitehouse (1936, p. 87, pl. VIII, figs. 10-12) but differs in minor details. Attention

may be called to some typical species of *Euagnostus* that recently have been described by Endo and Resser (1937, pp. 157-160, pl. 30) from the Mapan Formation of Manchoukuo under the names *Agnostus damesi* E. and R., *A. viator* E. and R., *A. ozakii* E. and R. and *A. liaotungensis* E. and R. These are all well rounded forms with wide pygidial grooves, as are the Australian forms, and presumably *Euagnostus* should be restricted to such types. The Asiatic and Australian forms together extend the range of *Euagnostus* through most of the Middle Cambrian.

Genus **HOMAGNOSTUS** Howell, 1935.

(= *Oncagnostus* Whitehouse, 1936.)

Genotype : *Agnostus pisiformis* var. *obesus* Belt.

In erecting the genus *Oncagnostus* (Whitehouse 1936, p. 84), of which the genotype was *Agnostus hoi* Sun, I regret that I overlooked *Homagnostus* Howell (1935, p. 15) which I regard as congeneric. The genus has been found in Scandinavia, Wales, North America (New Brunswick), China and Chosen. In all these places it occurs in the basal portion of the Upper Cambrian. I have now to record the genus in the same stage in the Upper Cambrian of Queensland.

HOMAGNOSTUS cf. **OBESUS** (Belt).

(Pl. XXV, figs. 17 and 18 (?).)

Four pygidia of a species of *Homagnostus* have been collected and certain cephala that may belong to the same species. Quite possibly they belong to *H. obesus*, which species is still inadequately known. Belt's original figures (1867, p. 295, pl. 12, fig. 4) are rather poor. His types, wherever they may be, have not been refigured, nor yet any topotypes. Lake (1906, part 1, p. 9, pl. 1, figs. 13 and 14) has published figures of other Welsh specimens and has suggested that *Agnostus pisiformis* var. *socialis* Tullberg (1880, p. 25) from Sweden is a synonym. Certainly these two forms are congeneric ; but more must be known of *H. obesus* before we can be sure of the specific relationship. Howell (1935, pl. 1, figs. 11 and 12) has recently figured a Swedish specimen[58] under the name *H. obesus.* That form has tiny marginal spines on the pygidium. Neither Belt nor Lake mention these on the Welsh specimens ; although, if present as a specific feature, they could easily be obscured by conditions of preservation. The tails now figured have incipient marginal spines. In most features these tails agree with *H. obesus* as we know it.

Two other species of *Homagnostus* are known—*H. hoi* Sun sp. (1924, p. 28, pl. 2, figs. 2) from China and *H. hoiformis* Kobayashi sp. (1933, p. 97, pl. 10, figs. 1-3)

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[58] Possibly a topotype of *Agnostus pisiformis* var. *socialis.*

from Chosen. The New Brunswick form which Howell has found has not yet been figured. The pygidial axis of *H. hoi* narrows to the rear[59] and in this way differs from the Australian, Welsh and Swedish forms. In *H. hoiformis* the axial furrows on the tail are obscure. In one feature, however, the Australian form may be compared more closely with *H. hoiformis* than with any other species. The cephala that are found with the Australian tails have a pair of discontinuous, posterior glabellar furrows. Such furrows, characteristic features of certain other genera of Agnostidae, for instance *Triplagnostus*, have been recorded only on one species of *Homagnostus*—*H. hoiformis*. That species, however, has no median, pre-glabellar furrow, such a furrow being present on the cephala of the Australian form and the other described species.

Thus if the associated cranidia and pygidia that now are figured belong to the same species it would be necessary to designate it by a new name ; but until this can be established[60] and until more is known of *H. obesus* a new name is not warranted.

Locality and horizon : From the *Rhodonaspis* Stage at the western base of Polly's Lookout, Glenormiston (University of Queensland Collection).

Family PHALACROMIDAE Corda, 1847.

Genus **PHALACROMA** Corda, 1847.

Genotype : *Phalacroma scutiforme* Corda.

PHALACROMA cf. **NUDUM** (Beyrich).

(Pl. XXV, figs. 28, 29.)

A typical *Phalacroma* is present in the beds of the *Papyriaspis* Stage, having the large pygidial rim characteristic of *P. nudum* and its allies. I have not had access to a copy of Beyrich's work[61] or seen any topotypes. Furthermore, as I have already indicated (1936, p. 94), there is some difficulty in equating the forms referred to *P. nudum* by later workers. Because of these things, and since the Queensland specimens, with the exception of one head, are badly crushed I leave the species for the present provisionally referred to *P. nudum*.

The specimens that I have collected are, with one exception, isolated heads and tails. One specimen (plate XXV, fig. 29) has head, thorax and pygidium conjoined, but it is imperfect and very badly crushed. As with the typical members of this group the head has a very narrow and the tail a wide rim.

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[59] This may not be a specific character ; for one of Sun's figures (2d) does not show it. If there is no constant narrowing then it remains to be shown how *H. hoi* differs from *H. obesus*.

[60] Such a head could belong also to a species of *Pseudagnostus* ; and tails of *Pseudagnostus* occur on the same rock specimens.

[61] E. Beyrich, 1845. Ueber einige böhmischen Trilobiten. *Berlin*.

Localities and horizon : One specimen (an uncrushed head) has been obtained from the beds of the *Papyriaspis* Stage at the road crossing of V Creek, between Undilla and Thorntonia. The majority of the specimens come from beds of the same stage a mile and a half west of this locality (University of Queensland Collection).

? Family TRINODIDAE Howell, 1935.

Genus **HYPAGNOSTUS** Jaekel, 1909.

Genotype : *Agnostus parvifrons* Linnarsson.

HYPAGNOSTUS CLIPEUS sp. nov.

(Pl. XXV, figs. 25, 26.)

Diagnosis : Cephalon subcircular. The major (median) glabellar lobe is slightly acuminate and has a rounded base. It is slightly more than one-third the length of the cephalon, and near its base is slightly more than one-third the total width. The accessory glabellar lobes are triangular, widening at the base to join, on the steeply descending slope, below the median lobe. The furrows around these lobes are prominently incised. The cephalic rim is narrow and uniform in width.

The two thoracic segments have wide axes and short pleura. The axis of each segment has a narrow furrow that begins at the posterior angles and reaches the anterior margin in the centre, thus dividing the surface into three inflated regions—a central, wide subtriangular area and two small, transversely subovate, lateral areas. The pleura are short, with blunt ends turned slightly forward. On each there is a narrow furrow dividing the pleuron into a narrow ridge and a broad, bulbous portion. On each anterior pleuron the furrow is posteriorly placed, and it is in the anterior position on each posterior pleuron, so that the bulbous portions are adjacent to the cephalon and pygidium.

Restoration.
(x. 3)

The pygidium is subcircular, with bevelled antero-lateral edges. It has a very broad axis that extends almost to the posterior rim. On it the transverse furrows and median tubercle are but faintly marked. The circumaxial furrow is prominent. There is no post-axial furrow. The rim is narrow, uniform and without spines.

Remarks : The most similar species is the genotype, *H. parvifrons* Linnarsson sp. (see Tullberg, 1880, pl. 2, figs. 26-28). The most pronounced differences are that in the latter species the cephalic and pygidial rims widen in the axial region while the pygidial axis reaches right to the rim. *H. brevifrons* Angelin sp. (see Tullberg, 1880, pl. 2, fig. 29), *H. exsculptus* (Angelin) and its variety *didymus* Wallerius sp. (1930, p. 58) have shorter pygidial axes. *H. vortex* Whitehouse (1936, p. 103, pl. 9, figs. 7, 8) which previously was described from Queensland, has a more quadrate outline.

When in 1909 Jaekel erected the genus *Hypagnostus* he proposed also the name *Metagnostus* for similar agnostids with short pygidial axes. As genotype of the latter he chose the Ordovician *M. erraticus* Jaekel, and suggested that the Middle Cambrian *Agnostus brevifrons* Angelin was congeneric. It is most unlikely that the two groups, Middle Cambrian and Ordovician, belong naturally to the one genus, since Upper Cambrian forms of this type do not seem to be known. I do not think it necessary, on present evidence, to place in separate genera *A. parvifrons* Linarsson (with pygidial axes reaching to the rim) and *A. brevifrons* Angelin (with short axes). Morphologically *H. clipeus* is intermediate between these two.

Locality and horizon : From beds of the *Papyriaspis* stage at the road crossing of V Creek, between Undilla and Thorntonia (N.W. Queensland). This is the type locality. The species is also present in beds of the same Stage, two miles west of this crossing of V Creek (University of Queensland Collection).

(C) Faunal and Stratal Correlations.

(a) *Summary.*

Since parts 1 and 2 of this series were published a few new faunas have been found in the Georgina Limestones and certain additions and corrections can be made to the lists previously issued. The following is the sequence of stages recognised at present in the trilobite beds of the region. No trilobites have yet been found in the latest beds—the Ninmaroo Limestones.

Division.	Stage.	Zonal Correlation.
Upper Cambrian	*Elathriella* Stage	*Orusia lenticularis*
	Rhodonaspis Stage *Glyptagnostus* Stage	*Olenus*
	Eugonocare Stage	*Agnostus pisiformis*
Middle Cambrian	*Anomocare* Stage	*Paradoxides forschammeri*
	Papyriaspis Stage *Phoidagnostus* Stage	*Paradoxides davidis*
	Agnostus seminula Stage	*Paradoxides hicksi*
	Dinesus State	*Ctenocephalus exsulans*
	Eurostina Stage	*Triplagnostus atavus*
	Amphoton Stage	*Paradoxides oelandicus*
Lower Cambrian	*Redlichia* Stage	

Such collecting that has been done in this vast area has been but the casual gleanings of a few reconnaissance journeys ; but already, even from these traverses, it has been found necessary to subdivide the zones of *Paradoxides davidis* and *Olenus*. When the area is adequately searched there can be little doubt that the zonal sequence, as based on the Scandinavian succession, will have to be considerably distended.

Two new stages have been added as a result of recent collecting—the *Agnostus seminula* Stage and the *Papyriaspis* Stage. Also, since the names of the new polymerid trilobites are now available, it has been necessary to change the designation of three stages that had been named somewhat provisionally in the previous paper. In this way the term "*Eurostina* Stage" replaces "*Inouyella* Stage," of the earlier list, "*Eugonocare* Stage" replaces "*Anorina* Stage," and "*Rhodonaspis* Stage" replaces "*Pagodia* Stage." The name "*Solenopleura* Stage" has been deleted from the list. The recognition of this Stage was based on a small collection of trilobites that I had received from Chatsworth Homestead. Since then I have visited the Chatsworth area, have collected from limestones on several parts of this huge property, but have found no limestones *in situ* around the homestead. Instead, about the homestead, there are limestone slabs, used for constructional purposes, that have been brought from several parts of the property. From which of these slabs the fossils were obtained I could not determine. There is, consequently, little purpose to be served by describing this small fauna, and it is better to suppress reference to it until fossils have been collected from actual outcrops.

(*b*) *Faunal Lists and Details of Correlations.*

i. The Redlichia Stage contains *Mesodema venulosa* and *Redlichia idonea*. The primitive nature of these forms suggests that the fauna is equivalent to an early part of the *Redlichia* sequence, as developed in Asia.

ii. The Amphoton Stage contains *Amphoton spinigerum* and *Nepea narinosa*. It is equivalent to the "*Dolichometopus*" band in the Cambrian of Victoria in which both *Amphoton* and *Nepea* occur. In North America the Nepeidae and *Glossopleura* (allied to *Amphoton*) occur in early Middle Cambrian beds, generally below those with *Pagetia*.[62] In the absence of other evidence the *Amphoton* Stage, in this list, is placed below the *Dinesus* Stage (with *Pagetia*).* A correlation with European zones is tentative, since neither genus is known in Europe. In China this group of *Amphoton* is typical of the Mapan Formation. For correlation purposes it may be noted that these beds in Queensland contain a species of the rare Cambrian and Ordovician brachiopod genus *Lingulodiscina*.

iii. The Eurostina Stage contains *Eurostina trigona*, *Xystridura sp.*, *Notasaphus* (?) *sp.* and *Anomocarella* (?) *sp.* It is a small and inadequately known fauna. It is believed to be intermediate between the *Eurostina* and *Dinesus* Stages since it contains elements of both—*Lingulodiscina* and *Xystridura*.

iv. The Dinesus Stage contains *Triplagnostus atavus*, *T. gibbus*, *Diplorrhina elkedraensis*, *D. normata*, *Pagetia significans*, *Paradoxides peregrinus*, *Xystridura browni*, *X. saint-smithi*, *Lyriaspis sigillum*, *L. alroiensis*, *Chancia vicenalis*, *Dinesus*

[62] In the Rennie Formation such forms occur together. Generally, however, they would seem to be in distinct faunas.

* Since the above was written Mr. D. E. Thomas has demonstrated to me in the field that in Victoria (at Knowsley) the *Amphoton* beds are below those with *Dinesus*.

ida, *Notasaphus modicus* and *Oryctocephalus discus*. In genera, species and individuals it is the richest fauna in the province. The type area is Beetle Creek (so named from the abundance of trilobites, locally known as "fossil beetles"), 12 miles north west of Mount Isa, where all these species occur except *Diplorrhina elkedraensis*, *Xystridura browni* and *Lyriaspis alroiensis*.[63] Elsewhere in the area *Diplorrhina elkedraensis* occurs with *Pagetia significans* and it is allied to *D. normata*. *Lyriaspis alroiensis* occurs in the Northern Territory with *Xystridura saint-smithi* and *Pagetia significans*, and it is allied to *L. sigillum*. These forms, therefore, legitimately may be added to the fauna of the *Dinesus* Stage. *Xystridura browni* is close to *X. saint-smithi* and it too is regarded as a member of this fauna. This is the earliest stage from which, locally, agnostid trilobites have been collected. It may be correlated with the "*Dinesus* beds" of the Cambrian of Victoria that contain both *Dinesus* and *Notasaphus*.

This is a curious fauna with generic elements that ally it to the faunas of the Asiatic, Cordilleran, Appalachian and Scandinavian Provinces. The agnostids, and such genera as *Pagetia*, *Paradoxides*, *Oryctocephalus* and *Notasaphus* stamp it as an early Middle Cambrian fauna. The presence of *Pagetia*, *Oryctocephalus* and *Lyriaspis* suggest that it may be correlated with part of the Stephen Formation of British Columbia and the "*Ptychoparia* Beds" of North West Korea. As noted previously the agnostids suggest an horizon approximately equivalent to the zone of *Ctenocephalus exsulans* in Europe.

v. THE AGNOSTUS SEMINULA STAGE.—In this Stage, for the present, I am grouping two faunas from the region north east of Yelvertoft Dip. Each contains only agnostid trilobites. From one bed I have collected, but the other I have not been able to discover. When more is known of the area it may be advisable to separate them. In a limestone eleven and a half miles north east of Yelvertoft Dip there occur *Agnostus seminula* and *Goniagnostus purus*, species that indicate the zone of *Paradoxides hicksi*. From some hilltop, approximately four miles further to the north east, in an area somewhat difficult to correlate, a fauna has been collected with *Triplagnostus atavus*, *Solenopleura acuminatus*, *Cotalagnostus* aff. *kushanensis*, and *Hypagnostus vortex*. From erroneous information that had been supplied to me I recorded these species, previously, as occurring in beds of the *Dinesus* Stage. The coexistence of *Triplagnostus atavus* and *Solenopleura acuminatus* suggests an horizon somewhere between the *Dinesus* and *Phoidagnostus* Stages, so that, for the time being, it can be grouped with the *Agnostus seminula* assemblage. The stratal difficulty of correlating this fauna is discussed in the following chapter.

vi. THE PHOIDAGNOSTUS STAGE contains *Solenagnostus acuminatus*, *Enetagnostus humilis*, *Lejopyge exilis*, *Phoidagnostus limbatus* and *Phalacroma* (?)

[63] It is perhaps doubtful, as mentioned elsewhere, whether this is really the locality for *Paradoxides peregrinus* and *Chancia vicenalis*. If not obtained from this place they probably came from near by, in an area where no other faunas are yet known.

dubium. Only one rather indefinite polymerid fragment has been found. Nothing further is to be added to the reasons previously given for correlating this with the zone of *Paradoxides davidis*.

vii. THE PAPYRIASPIS STAGE contains *Ceratagnostus magister*, *Goniagnostus nathorsti*, *G. scarabeus*, *Euagnostus sp.*, *Hypagnostus clipeus*, *Phalacroma* cf. *nudum*, *Papyriaspis lanceola*, *Asthenopsis levior*, *Amphoton serotinum* and *Anomocare* (?) *angustum*. The coexistence of *Phalacroma* and *Euagnostus* suggests an horizon between the *Phoidagnostus* and *Anomocare* Stages. The presence of *Ceratagnostus* and of *Goniagnostus* cf. *nathorsti* indicate the zone of *Paradoxides davidis*. Such a correlation accords with the presence of *Asthenopsis* (ranging from the zone of *Paradoxides hicksi* to the zone of *P. forschammeri*), a species of Anomocaridae not far removed from *Anomocare* and the group of *Hypagnostus* represented by *H. clipeus*. The faunas of this Stage have been collected from two localities, in the V Creek area, about a mile and a half apart. On field evidence these beds seem to be separated by some thickness of strata. One fauna has yielded abundant *Asthenopsis* and *Papyriaspis* but no *Amphoton*, while the other has abundant *Amphoton* but no *Papyriaspis* or *Asthenopsis*. Possibly some division of this Stage may be made when more intense field work is carried out. The occurrence of *Amphoton* so far above the *Amphoton* Stage agrees with the evidence in Manchoukuo, where it occurs on two horizons—in the Mapan Formation and in the Taitzu.

viii. THE ANOMOCARE STAGE contains *Euagnostus opimus*, *Phalacroma* (?) *sp.* and *Anomocare confertum*. The Stage is equated with the zone of *Paradoxides forschammeri* because of typical *Anomocare* which, in Europe, appears to be restricted to this horizon.

ix. THE EUGONOCARE STAGE contains *Pseudagnostus vastulus*, *Eugonocare tessellatum*, *E. propinquum*, *Rhodonaspis sp.*, *Corynexochus plumula*, *Charchaqia erugata*, *C. spp.*, *Proceratopyge lata* and *P. rutellum*. This assemblage indicates the zone of *Agnostus pisiformis* at the base of the Upper Cambrian. *Proceratopyge* is an early Upper Cambrian genus, ranging down into the top zone of the Middle Cambrian. *Pseudagnotus* elsewhere is early Upper Cambrian, appearing first in the zone of *A. pisiformis*. *Charchaqia* is very close to *Eoasaphus* at the base of the Upper Cambrian. *Corynexochus* in Europe is a Middle Cambrian genus, ending at the top of the Middle Cambrian. Since the remainder of this fauna is so typically basal Upper Cambrian it suggests that *Corynexochus* here extends one Stage further into the zone of *A. pisiformis*.

x. THE GLYPTAGNOSTUS STAGE contains *Glyptagnostus toreuma*, *Pseudagnostus* cf. *cyclopyge*, *Proceratopyge nectans* and *Olenus* (?) *sp.* This is equated with the *Olenus* zone in Europe and the *Cedaria* zone in the Appalachian province, to each of which the genus *Glyptagnostus* is restricted.

xi. THE RHODONASPIS STAGE contains *Homagnostus* cf. *obesus*, *Pseudagnostus sp.*, *Proceratopyge polita*, *Rhodonaspis longula*, *R. prosecta*, and apparently also *Idamea venusta*. Containing *Pseudagnostus* and *Proceratopyge*, and underlying beds (the *Elathriella* Stage) with *Pseudagnostus*, this is still in the early Upper Cambrian. It seems best to regard it as the upper portion of the *Olenus* zone or the lower part of the zone of *Orusia lenticularis*. The specimens of *Idamea venusta* were collected, in the region where beds of the *Rhodonaspis* Stage are known, by the late Mr. B. Dunstan. I have not found this faunule in the field ; but tentatively I leave it in the *Rhodonaspis* Stage.

xii. THE ELATHRIELLA STAGE contains *Pseudagnostus nuperus*, *Aspidagnostus parmatus*, *Elathriella plebeia*, *E. sp.*, *Idamea superstes* and *Olenus* (?) *sp.* The most probable horizon for these beds is the zone of *Orusia lenticularis*, which seems to make the end, in Europe, of the range of *Pseudagnostus*.

(*c*) *Some Stratal Aspects.*

Grabau, on the basis of his Pulsation Theory, has suggested that there is a hiatus and disconformity in the Georgina Limestones between the Middle and Upper Cambrian horizons and (Grabau 1937, p. 378) he questions the occurrence of *Corynexochus* in the *Eugonocare* Stage, suggesting that it is a remané fossil from lower beds. But, as I have shown, it is an essential and contemporary member of this fauna. For that reason, and also for the strong argument of the lithological unity of the Georgina Limestones, I see no reason for postulating such a break.

A few words are necessary on the earliest fossiliferous Cambrian beds in the Yelvertoft area. In that region where the Cambrian beds are more or less horizontal they rest on quartzites, dipping at varying angles, of late Pre-Cambrian age. Around Yelvertoft homestead, and in the area about 16 miles north east of Yelvertoft dip the Cambrian beds consist of fragments of cherts and silicified shales resting on these earlier quartzites. Around the homestead these cherts have yielded abundant fossils, but only of *Redlichia*, *Aluta* and one specimen of *Mesodema*. They would not appear, therefore, to be a resorted rubble. In the region north of Yelvertoft dip three faunas in these cherts have been obtained in a small area. At the base of a hill a collection of only *Redlichia* was obtained. On the top of a hill, perhaps 50 feet higher than the other bed, a fauna yielded only members of the *Dinesus* Stage (*Xystridura saint-smithi* and *Pagetia significans*). From the top of another nearby hill Mr. Dalling of Yelvertoft has collected the agnostid fauna with *Solenagnostus*, mentioned above in the section dealing with the *Agnostus seminula* Stage. Again there is no admixture with other faunas. There seems to be in this region a condensed sedimentary succession of cherts, resting on these Pre-Cambrian beds, or else (since fossiliferous limestones

with chert bands occur close by) they represent a series of limestones, with chert bands, from which the calcareous material has been removed by solution, leaving the cherts remaining, in their original although condensed sequence, as fragments on the older rocks. It is a curious local problem on which field work is required.

(*d*) *A Palaeogeographic Note.*

The outstanding palaeogeographical feature of this province is that the faunas have relationships in most of the other major Cambrian provinces that have been defined. In the beginning, in the *Redlichia* Stage, the faunas are entirely Asiatic in character, agreeing with those of the Himalayan and Cathayan Provinces. As in those regions no trilobites are known before the *Redlichia* Stage. Thereafter, until the *Eugonocare* Stage, there are still Asiatic elements in the fauna (*Amphoton*, *Lyriaspis* and Papyriaspidae, for instance), but genera characteristic of other provinces make their appearance. From the *Dinesus* Stage onwards there is a close faunal comparison to be made with the Atlantic Province, particularly with the Scandinavian area and its extension into the boreal regions of Bennett Island. Some elements of the faunas indicate relationships with the Appalachian Province and its northerly extension into Greenland and other boreal areas. Nepeidae and *Elathriella* are two such elements. The presence of a rich *Ellesmereoceras* horizon in the Ninmaroo Limestones indicates a faunal analogy with that province, and with Manchoukuo, at the end of the Cambrian.

It may be that the marine areas of the continents were geosynclines at this period, much in the manner that Grabau (1937, pl. III) has postulated ; but if so I do not think it necessary to believe that these fluctuating faunal relationships with the several provinces indicate migrating geosynclines. The Australian region is one of the most southerly Cambrian provinces ; and if it should have been (as is indicated on so many palaeogeographical maps that have been drawn for the Cambrian) that many of the northerly geosynclines opened into a southern sea or ocean, this would permit of free transport of larval life by marine currents into the southern sea beside the Australian geosynclines. Then as facies, and particularly climatic facies, fluctuated the relationships of the Australian Cambrian faunas would fluctuate too, having relationships now with one province, now with one or several of the others. That, I suggest, is an explanation of these relationships in the light of our present knowledge of Cambrian ecology.

And thus future work in extending our knowledge of the Australian Cambrian faunas may have two important results—it may, from community of relationships, allow correlations to be made between other Provinces that are themselves distinct, and it may shed an important light on the variations in climatic facies during the period.

5. LOCALITIES.

In the very sparsely settled region where these collections were made localities have had to be recorded in terms that will have little significance unless one has access to the four-mile maps of the region. Care has been taken to define the localities in such a way that they may be found by later workers visiting the region; while for general purposes I append the latitude and longitude, recorded as far as possible to the nearest minute, of a number of key localities. By comparison with this list any locality recorded in the text may be fixed upon the map. There are few localities in this table that can be stated in terms more accurate than one minute of latitude and longitude. The list is as follows:

Alexandria—homestead	E. 136° 42′; S. 19° 03′
Alroy Downs—homestead	E. 136° 04′; S. 19° 18′
Alroy Downs—No. 1 bore	E. 136° 15′; S. 19° 15′
Alroy Downs—No. 4 bore	E. 136° 14′; S. 19° 28′
Camooweal	E. 138° 07′; S. 19° 55′
Chatsworth—homestead	E. 140° 18′; S. 21° 58′
Chatsworth—mouth of Lily Creek	E. 140° 17′; S. 22° 00′
Devoncourt—homestead	E. 140° 14′; S. 21° 13′
Duchess	E. 139° 52′; S. 21° 22′
Elkedra—homestead	E. 135° 36′; S. 21° 07′
Glenormiston—homestead	E. 138° 48′; S. 22° 55′
Glenormiston—Polly's Lookout	E. 138° 56′; S. 23° 05′
Glenormiston—No. 17 bore	E. 138° 29′; S. 22° 53′
Glenormiston—20-mile bore	E. 138° 51′; S. 23° 13′
Glenormiston—Tyson's bore	E. 138° 43′; S. 23° 01′
Herbert Downs—homestead	E. 139° 15′; S. 23° 02′
Thorntonia—homestead	E. 138° 55′; S. 19° 30′
Warenda—Black Mt. (Ninmaroo)	E. 140° 16′; S. 22° 33′
Warenda—Unbunmaroo	E. 140° 16′; S. 22° 38′
Warenda—Mt. Datson	E. 140° 25′; S. 22° 47′
Yelvertoft—homestead	E. 138° 53′; S. 20° 12′
Yelvertoft—dip (Old Yelvertoft)	E. 138° 48′; S. 20° 06′
Beetle Creek (on Thornton River)[64]	E. 139° 20′; S. 20° 37′
"Split Rock" on Waroona Creek	E. 138° 29′; S. 19° 59′
Road crossing of V Creek (Undilla to Thorntonia)	E. 138° 44′; S. 19° 34′
Road crossing of Harris Creek (Camooweal to Old Thorntonia)	E. 138° 43′; S. 19° 26′

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[64] This locality, about 12 miles north west of Mt. Isa, was referred to previously (Whitehouse, 1936) as "Thornton River."

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7. EXPLANATION OF PLATES.

PLATE XIX.

(All figures natural size except figs. 2b, 5b and 6.)

Fig. 1. *Mesodema venulosa* sp. nov. Holotype (page 190).

From Yelvertoft Homestead (*Redlichia* Stage).

a is the broken edge of the palpebral lobe as it arises from the frontal lobe of the glabella.
b is the post-palpebral surface, arising from the second glabellar lobe.

Figs. 2–11. *Redlichia idonea* sp. nov. (page 191).

From Yelvertoft Homestead (*Redlichia* Stage).

2a, b. A small individual. The depression on the glabella probably corresponds with the position of the hypostome. Fig. 2b is enlarged three diameters.

3. Another specimen similar to 2a.

4. The holotype.

5a, b. An internal mould with curious segmental structures. 5a shows the entire specimen, with eight thoracic and two cephalic processes, the anterior of the two cephalic structures being considerably larger than the others. 5b, enlarged three diameters, shows, in detail, the three posterior processes of 5a. In 5a, on the cephalon, there is the cranidium of a second, smaller, individual.

6. The most complete specimen found—a young individual (magnified three diameters).

7, 8 and 9. Cranidia of three individuals of average size.

10. The posterior portion of the test, showing the spine arising from the axis on the eleventh thoracic segment.

11. A larger specimen showing the thoracic spine.

The originals of figures 1, 3, 4, 5, 6, 7, 8 and 11 are in the University of Queensland Collection. The original of figures 2, 9 and 10 are in the Schmidt Collection, on loan to the University of Queensland.

PLATE XX.

(All figures natural size except fig. 6.)

Figs. 1–5. *Redlichia idonea* sp. nov. (page 191). Five specimens of large size from Yelvertoft Homestead (*Redlichia* Stage).

1. The largest cranidium.
2. Portion of a thoracic axis.
3. A free cheek.
4. A hypostome attached to the rostrum.
5. A pygidium.

Fig. 6. *Paradoxides peregrinus* sp. nov. Holotype (x. 10) (page 194).

From the Templeton River area, north west of Mount Isa (*Dinesus* Stage).

The originals of figs. 1 and 2 are in the Schmidt Collection, on loan to the University of Queensland ; figs. 3, 4 and 5 in the University of Queensland Collection ; fig. 6 in the collection of the Geological Survey of Queensland.

PLATE XXI.

(All figures natural size except figs. 4 and 16.)

Fig. 1. *Xystridura browni* (Etheridge fil.), holotype (page 198).

From the spoil heap of a well, 5 miles north of Alexandria Homestead (*Dinesus* Stage).

Figs. 2–16. *Xystridura saint-smithi* (Chapman). (page 199).

2. Holotype of species. From Beetle Creek, 12 miles north west of Mount Isa (*Dinesus* Stage).

3a and 4. Holotype of "*Bathyuriscus nitidus*" Chapman. Fig 4 is enlarged two diameters. Same locality and horizon.

3b. Holotype of "*Bathyuriscus olenelloides*" Chapman. Same locality and horizon.

5. Holotype of "*Marjumia milesi*" Chapman. Same locality and horizon.

6. Holotype of "*Marjumia conspicabilis*" Chapman. From Shepherd Creek, near Miles Creek, north branch of the Templeton River (*Dinesus* Stage).

7. Paratype of "*Marjumia conspicabilis*" Chapman. Same locality and horizon.

8. Holotype of "*Marjumia elegans*" Chapman. From Beetle Creek, 12 miles north west of Mount Isa (*Dinesus* Stage).

9. Holotype of "*Dikelocephalus dunstani*" Chapman. From the Thornton River (*Dinesus* Stage).

10. Holotype of "*Milesia templetonensis*" Chapman. From Beetle Creek, 12 miles north west of Mount Isa (*Dinesus* Stage).

11. Complete specimen, rather narrower than usual. Same locality and horizon.

12. A typical, complete specimen. Same locality and horizon.

13. A cranidium and part of the thorax. In the upper part, a hypostome. Same locality and horizon.

14. A hypostome attached to part of the rostrum. Same locality and horizon.

15. The pygidium of a large specimen, with the last thoracic segment attached. Same locality and horizon.

16. The two smallest specimens examined (x. 3). Same locality and horizon. Note the long genal spines and the meta-cranidial spines.

The original of fig. 1 is in the Australian Museum Collection; fig. 2 in the collection of the Commonwealth Geological Survey, Canberra; figs 3–10 in the collection of the Geological Survey of Queensland; fig. 11 in the private collection of Mr. J. Wadley; figs. 12–16 in the University of Queensland Collection.

PLATE XXII.

(Figures natural size, unless otherwise stated.)

Figs. 1, 2. *Xystridura saint-smithi* (Chapman). (page 199).

1. An internal mould on which the following features may be noted: The wide doublure of the thorax; the doublure of the cephalon extending around the genal angle; the rostrum extending into the angle formed by the doublure near the genal angle; the hypostome in place.

From the *Dinesus* Stage of Beetle Creek, 12 miles N.W. of Mount Isa.

2. A worn specimen from the No. 1 bore, Alroy Downs (*Dinesus* Stage).

Figs. 3–5. *Lyriaspis sigillum* sp. nov. (page 204).

3. The holotype (x. 2).
4. A specimen minus the free cheeks (x. 2).
5. An incomplete specimen.

From the *Dinesus* Stage of Beetle Creek, 12 miles N.W. of Mount Isa.

Fig. 6. *Lyriaspis alroiensis* (Etheridge fil.). Holotype (page 203).

Specimen preserved on an aboriginal artefact picked up at 8 miles east of Alroy Downs. The species is a member of the *Dinesus* Stage fauna.

Fig. 7. *Chancia vicenalis* sp. nov. Holotype (page 205).

From the *Dinesus* Stage of the Templeton River area, probably from Beetle Creek.

Figs. 8, 9. *Elathriella plebeia* sp. nov. (page 207).

8. Holotype, a cranidium (x. 2).
9. An immature individual (x. 4).

From the base of a hill immediately west of Tyson's Bore, Glenormiston (*Elathriella* Stage).

Fig. 10. *Elathriella sp.* (x. 2) (page 208).

Locality and horizon as for figs. 8, 9.

Figs. 11a, b. *Eurostina trigona* sp. nov. Holotype (page 209).

11a. The cranidium magnified 2 diameters.

11b. The same (x. 4).

From the *Eurostina* Stage of No. 4 Bore, Alroy Downs.

Figs. 12a, b and 13. *Protemnites elegans* sp. nov. (page 210).

12. Two cranidia. The larger is the holotype. Fig. 12a is x. 2 ; fig. 12b is x. 4.
13. A pygidium (x. 4).

Locality and horizon as for figs. 8, 9.

Fig. 14. *Anomocarella* (?) *sp.* (page 227).

A cranidium from the same locality and horizon as figs 11a, b.

Figs. 15a, b and 16. *Nepea narinosa* sp. nov. (page 212).

15a The holotype (a cranidium).

15b. The same (x. 2).

16. Another cranidium.

From the *Amphoton* Stage of the road crossing of Waroona Creek (" Split Rock ") between Camooweal and Mount Isa.

Figs. 17–20. *Asthenopsis levior* sp. nov. (page 214).

17. Holotype, a complete individual.
18. The cranidium of a larger specimen.
19. A pygidium.
20. Thorax and pygidium.

From limestones of the *Papyriaspis* Stage at the road crossing of V Creek, between Undilla and Thorntonia.

The original of figure 6 is in the collection of Mr. A. L. Merrotsy. The original of figure 7 is in the collection of the Geological Survey of Queensland. All other specimens are in the collections of the University of Queensland.

PLATE XXIII.

(All figures natural size unless otherwise stated.)

Figs. 1–8. *Papyriaspis lanceola* sp. nov. (page 218).

1. Holotype (x. 2).
2, 3. Other moderately complete specimens (x. 2).
4. A young individual (x. 2).
5, 6. Cranidia.
7. Thorax and pygidium.
8. Pygidium of a large specimen.

From the *Papyriaspis* Stage at the road crossing of V Creek, between Undilla and Thorntonia.

Fig. 9. *Rhodonaspis longula* sp. nov. (x. 2). Holotype (page 220).

About two miles south of Tyson's Bore, Glenormiston (*Rhodonaspis* Stage).

Figs. 10–12. *Rhodonaspis prosecta* sp. nov. (page 220).

10. A cranidium, the holotype, (x. 2).
11, 12. Pygidia (x. 2).

From the *Rhodonaspis* Stage at the base of Polly's Lookout, Glenormiston.

Fig. 13. *Rhodonaspis sp.* (x. 2) (page 221).

A fragmentary cranidium from the *Eugonocare* Stage, five miles north of the 20 Mile Bore, Glenormiston.

Fig. 14. *Olenus* (?) *sp.* (page 222).

A cranidium from the *Elathriella* Stage at the base of a hill immediately west of Tyson's Bore, Glenormiston.

Figs. 15–18. *Eugonocare tessellatum* sp. nov. (page 226).

15. Holotype (a cranidium), (x. 3).
16 and 17. Two pygidia (16 is magnified two diameters).
18. A free cheek.

From the *Eugonocare* Stage about four and a half miles north of the 20 Mile Bore Glenormiston.

Figs. 19, 20. *Eugonocare propinquum*, sp. nov. (page 227).

19. A pygidium (the holotype), (x. 2).
20. A cranidium.

From the *Eugonocare* Stage, five miles north of the 20 Mile Bore, Glenormiston.

Fig. 21. *Anomocare* (?) *angustum* sp. nov. Holotype (x. 2) (page 224).

From the *Papyriaspis* Stage at the road crossing of V Creek, between Undilla and Thorntonia.

Figs. 22–28. *Anomocare confertum* sp. nov. (All figures x. 2) (page 222).

22–24. Cranidia. Fig. 22 is the holotype. On 23 and 24 portions of the pre-glabellar field are preserved.
25–27. Portions of pygidia.
28. A free cheek.

From the *Anomocare* Stage five miles east of the road crossing of Harris Creek, between Camooweal and Old Thorntonia.

All specimens figured on this plate are in the University of Queensland Collection.

PLATE XXIV.

(All figures natural size unless otherwise stated.)

Figs. 1–3. *Dinesus ida* Etheridge fil. (page 229).

1. A complete individual, slightly flattened.
2. A specimen complete except for the posterior portion.
3a. An exterior (a wax squeeze of an external mould) and 3b an internal mould of the same specimen.

From the *Dinesus* Stage of Beetle Creek, 12 miles north west of Mount Isa.

Figs. 4–6. *Idamea venusta* sp. nov. (page 232).

4 and 5. Cranidia (x. 4). Fig. 4 is the holotype.
6. A pygidium (x. 4).

From the *Rhodonaspis* Stage fourteen miles south of Glenormiston homestead.

Fig. 7. *Idamea superstes* sp. nov. Holotype (x. 4) (page 233).

A cranidium from the *Elathriella* Stage at the base of a mill, immediately west of Tyson's Bore, Glenormiston.

Figs. 8–10. *Corynexochus plumula* sp. nov. (page 234).

8. Holotype, a cranidium (x. 8).
9. A pygidium (x. 10).
10. A pygidium (x. 6).

From the *Eugonocare* Stage, four and a half miles north of the 20 Mile Bore, Glenormiston.

Figs. 11, 12. *Ellipsocephalus (?) sp.* (page 231).

Two very small cranidia. Fig. 11 x. 10; fig. 12 x. 20.

From the *Eugonocare* Stage five miles north of the 20 Mile Bore, Glenormiston.

Figs. 13–20. *Amphoton spinigerum* sp. nov. (page 236).

13–15. Cranidia. Figs. 14a and 14b are two views of the holotype.
16. A pygidium.
17, 18. Free cheeks.
19. Portion of the combined cranidium and free cheek.
20. A thoracic segment, showing the long, axial spine.

From the *Amphoton* Stage of "Split Rock" on Waroona Creek, at the main road crossing between Camooweal and Mount Isa.

Figs. 21–23. *Amphoton serotinum* sp. nov. (page 238).

21a, b. Two figures of the holotype, a cranidium. 21b is natural size (a photograph of a wax squeeze of the external mould). 21a is slightly enlarged and is a photograph of the internal mould.
22. A pygidium (x. 2).
23. Two cranidia (x. 2).

From the *Papyriaspis* Stage, a mile and a half west of the road crossing of V Creek, between Undilla and Thorntonia.

The original of figures 4, 5 and 6 are in the collections of the Geological Survey of Queensland. All other specimens are in the University of Queensland Collection.

PLATE XXV.

(All figures natural size unless otherwise stated.)

Figs. 1–3. *Notasaphus modicus* sp. nov. (page 243).

1. Holotype.
2. A cranidium.
3. A pygidium.

From the *Dinesus* Stage of Beetle Creek, 12 miles north west of Mount Isa.

Figs. 4, 5. *Notasaphus fergusoni* Gregory, the genotype of *Notasaphus*, shown for comparison. (page 241).

4. A cranidium.
5. The lectotype, a pygidium.

From the *Dinesus* Stage of Knowsley in Victoria.

Figs. 6 and 7a. *Charchaqia erugata* sp. nov. Holotype (page 239).

Fig. 6 is magnified by four diameters and fig. 7a by three. On the left of 7a a free cheek and a pygidium can be seen.

From the *Eugonocare* Stage, four and a half miles north of the 20 Mile Bore Glenormiston.

Fig. 7b. *Eugonocare tessellatum* sp. nov. Holotype (x. 3), (page 226).

From the *Eugonocare* Stage about four and a half miles north of the 20 Mile Bore, Glenormiston.

Figs. 8a, b. *Proceratopyge nectans* sp. nov. (page 249).

8a. Holotype, a cranidium (x. 2).
8b. A pygidium (x. 2).

From the *Glyptagnostus* Stage, 16 miles south of Glenormiston homestead.

Figs. 9–11. *Proceratopyge rutellum* sp. nov. (page 250).

9. A cranidium, the holotype (x. 2).
10. Another cranidium.
11. A pygidium (x. 2).

From the *Eugonocare* Stage. Figs. 10 and 11 are from $4\frac{1}{2}$ miles north of the 20 Mile Bore, Glenormiston. Fig. 9 is from half a mile further north.

Fig. 12. *Proceratopyge lata* sp. nov. Holotype (x. 2). (page 248).

From the *Eugonocare* Stage five miles north of the 20 Mile Bore, Glenormiston.

Fig. 13. Pygidium belonging to either *Proceratopyge lata* or *P. rutellum* (x. 2).

From the same locality and horizon as figs. 9 and 12.

Fig. 14. *Proceratopyge polita* sp. nov. Holotype (x. 3), (page 251).

From the *Rhodonaspis* Stage, at the western base of Polly's Lookout, Glenormiston.

Fig. 15. *Oryctocephalus discus* sp. nov. Holotype, a cranidium (x. 2), (page 252).

From the *Dinesus* Stage of Beetle Creek, 12 miles north west of Mount Isa.

Fig. 16. *Elathriella plebeia* sp. nov. A cranidium (x. 2). (page 207).

From the *Elathriella* Stage at the base of a hill immediately west of Tyson's Bore, Glenormiston.

Figs. 17, 18. *Homagnostus* cf. *obesus* (Belt). (page 261).

17. A cranidium doubtfully associated with the species. (x. 3).
18. A pygidium of the typical *Homagnostus* form (x. 3).

From the *Rhodonaspis* Stage at the western base of Polly's Lookout, Glenormiston.

Fig. 19. *Goniagnostus scarabeus* sp. nov. Holotype (x. 3), (page 260).

From the *Papyriaspis* Stage at the road crossing of V Creek, between Undilla and Thorntonia

Fig. 20. *Goniagnostus* cf. *nathorsti* (Brögger) (x. 3), (page 259).

From the same stage as fig. 19, but from a mile and a half further west.

Figs. 21–23. *Goniagnostus purus* sp. nov. (page 258).

21. A cephalon (x. 6) showing traces of pleural furrows near the margin.
22. A cranidium with smooth pleura, the usual type (x. 4).
23. A pygidium (x. 4), the holotype.

From the *Agnostus seminula* Stage, eleven and a half miles north of Yelvertoft Dip, on the road to the Paradice Goldfield.

Fig. 24. *Agnostus seminula* sp. nov. Holotype (x. 3), (page 254).

From the same locality and stage as figs 21–23.

Figs. 25–26. *Hypagnostus clipeus* sp. nov. (page 263).

25. Holotype (x. 4).
26. Paratype (x. 3).

From the *Papyriaspis* Stage at the road crossing of V Creek, between Undilla and Thorntonia.

Fig. 27. *Ceratagnostus magister* sp. nov. Holotype. (x. 3), (page 256)

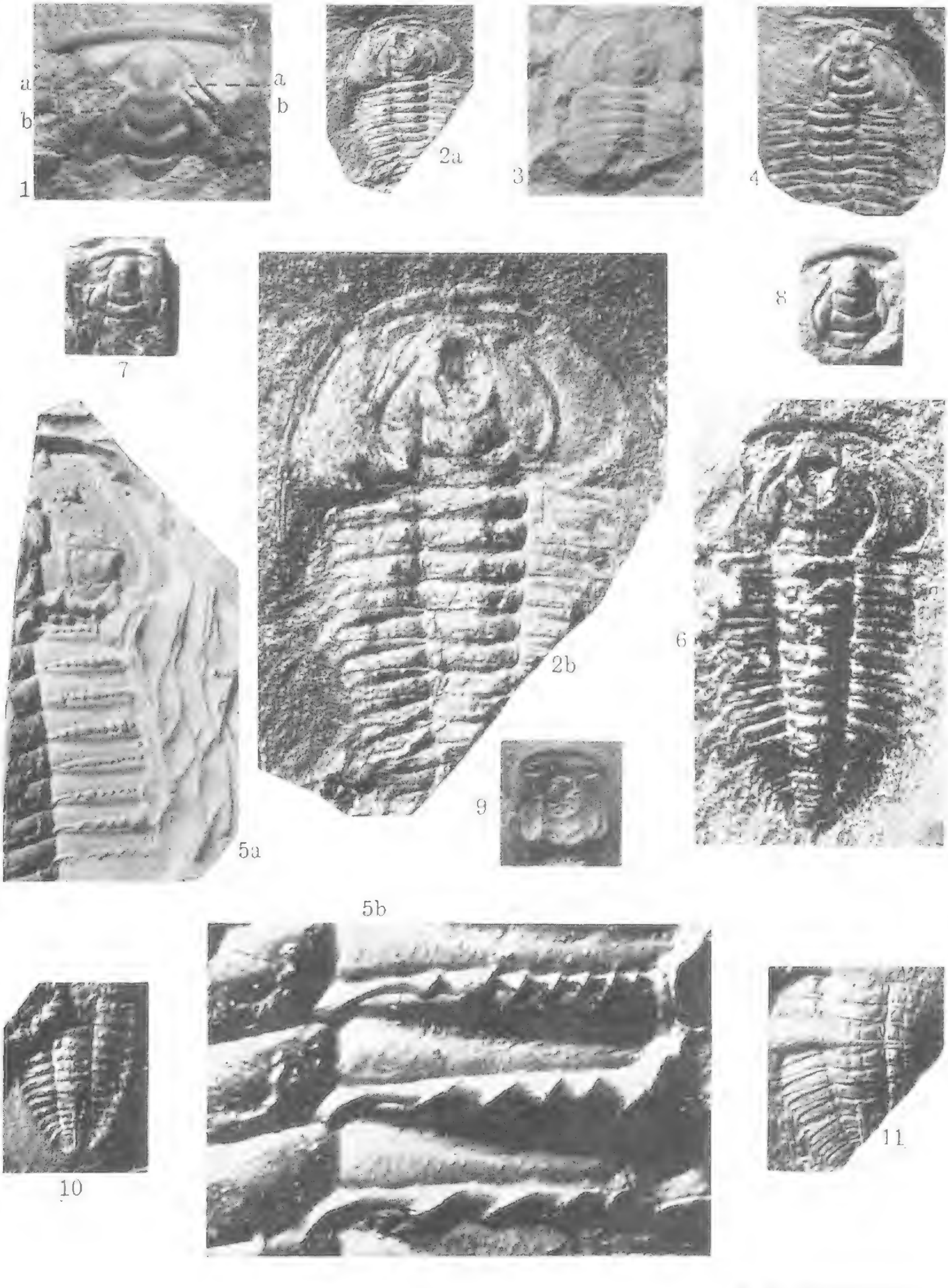
From the same stage and locality as figs. 25–26.

Figs. 28, 29. *Phalacroma* cf. *nudum* (Beyrich). (x. 4), (page 262).

28. A pygidium.
29. A crushed and imperfect specimen with head, thorax and tail preserved.

From the *Papyriaspis* Stage a mile and a half west of the road crossing of V Creek, between Undilla and Thorntonia.

Specimens 4 and 5 in the collection of the Geological Survey of Victoria. All other specimens in the University of Queensland Collection.



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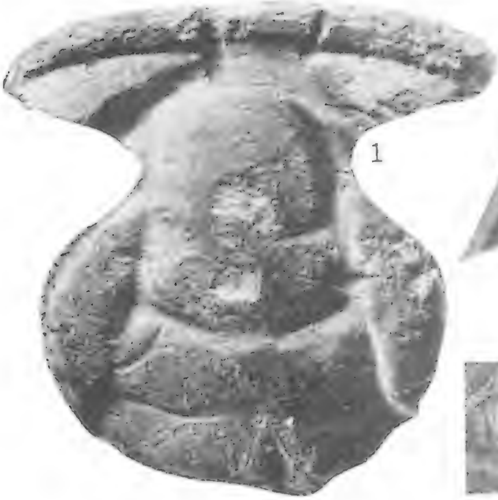

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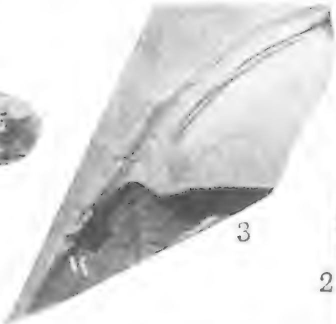

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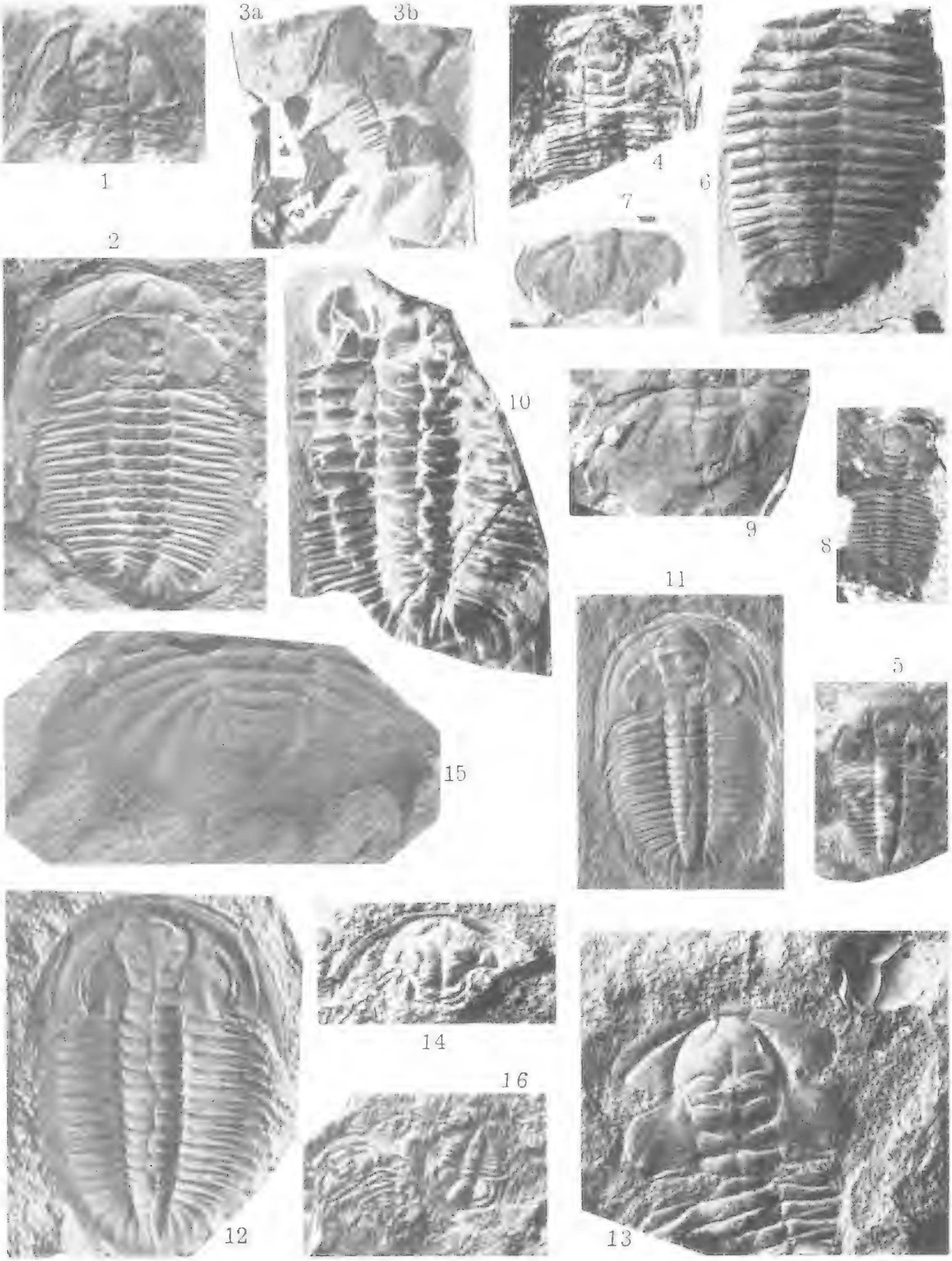

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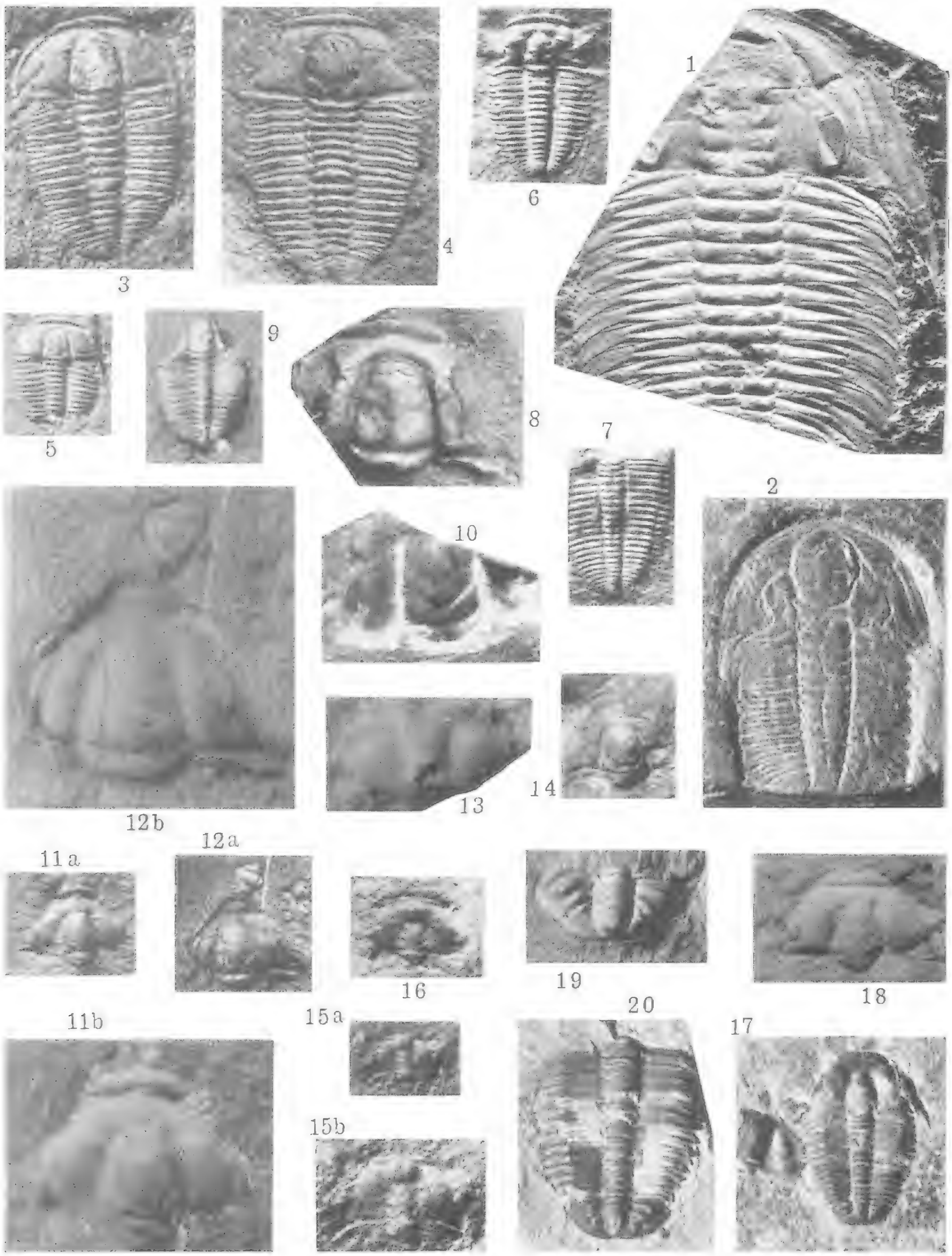

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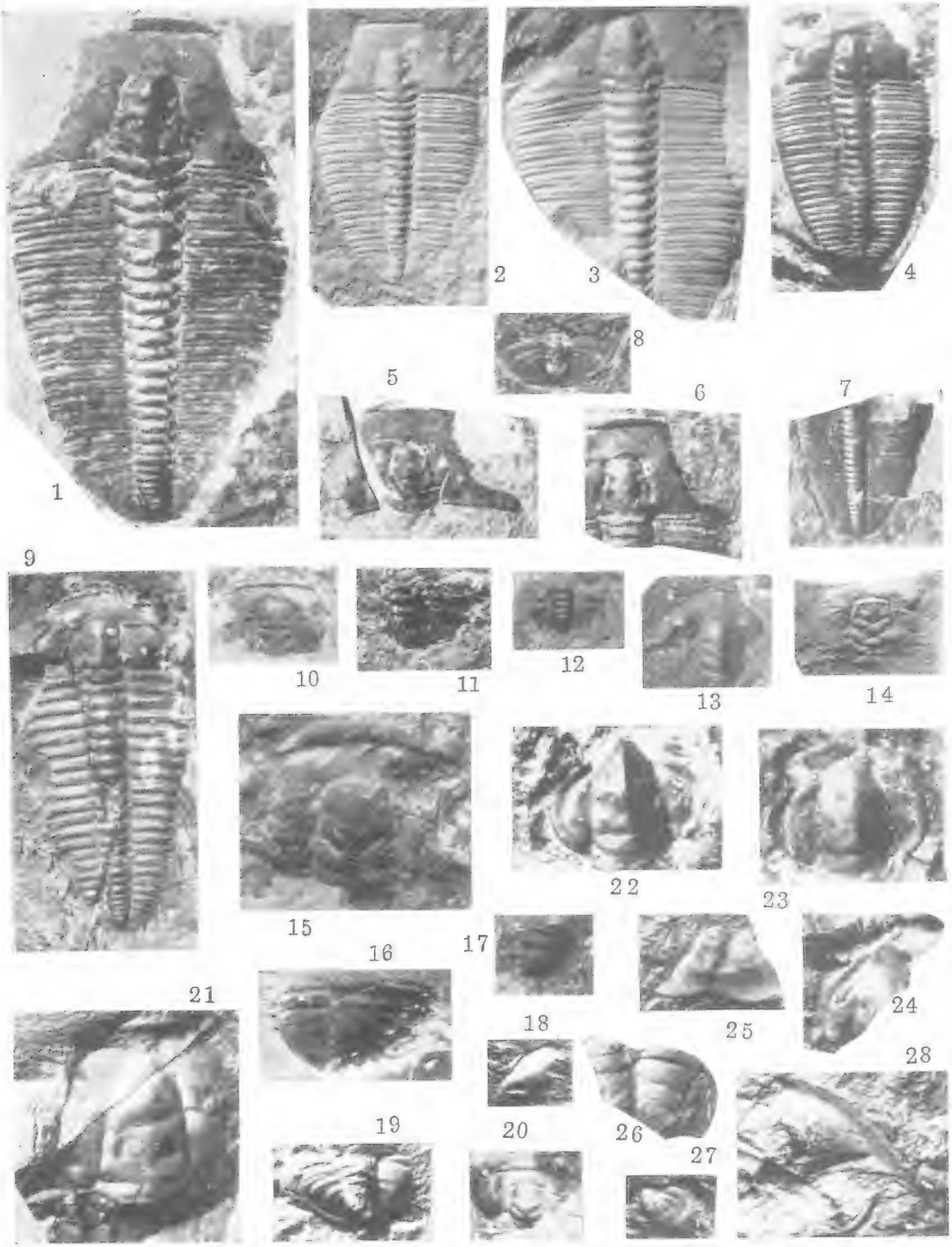

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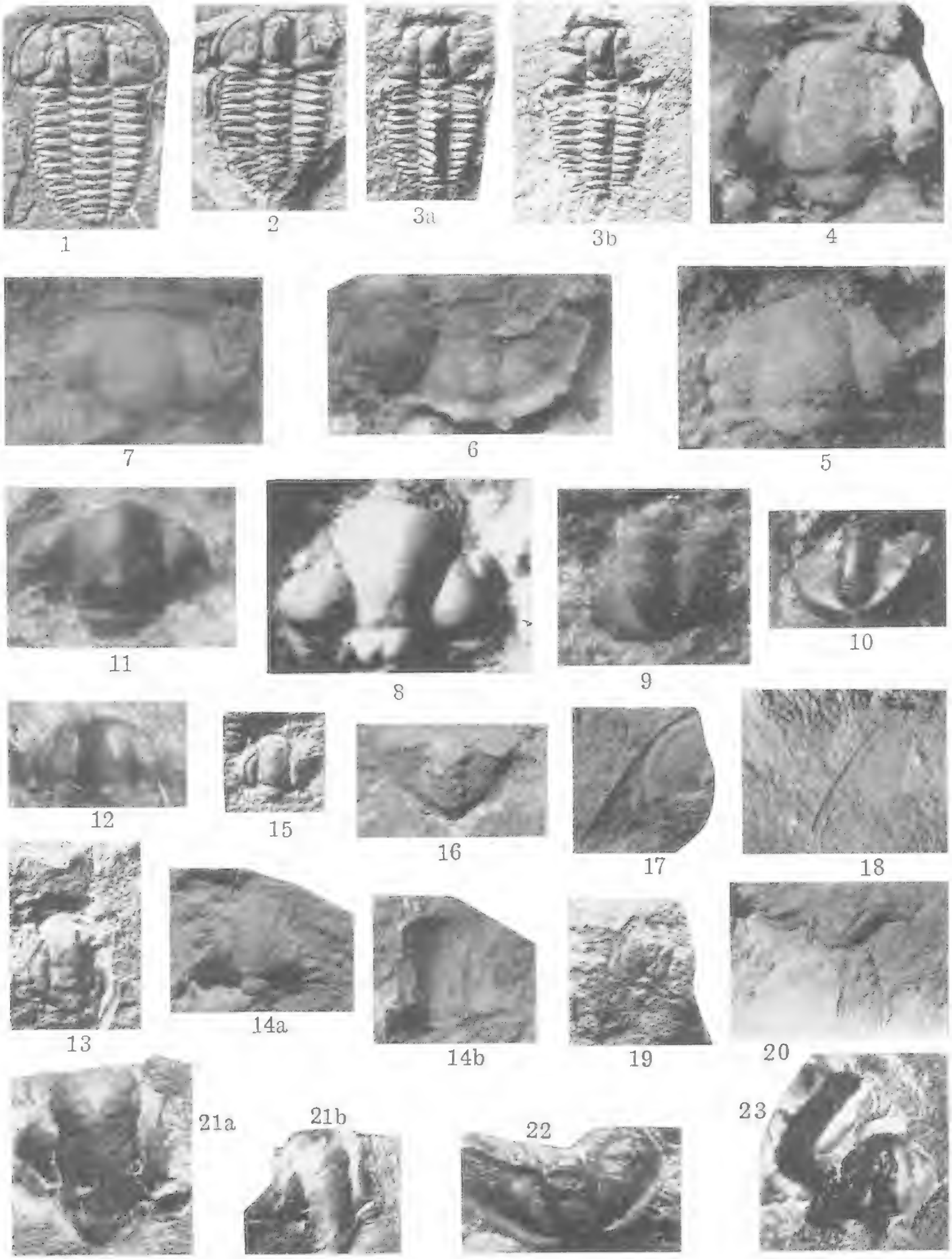

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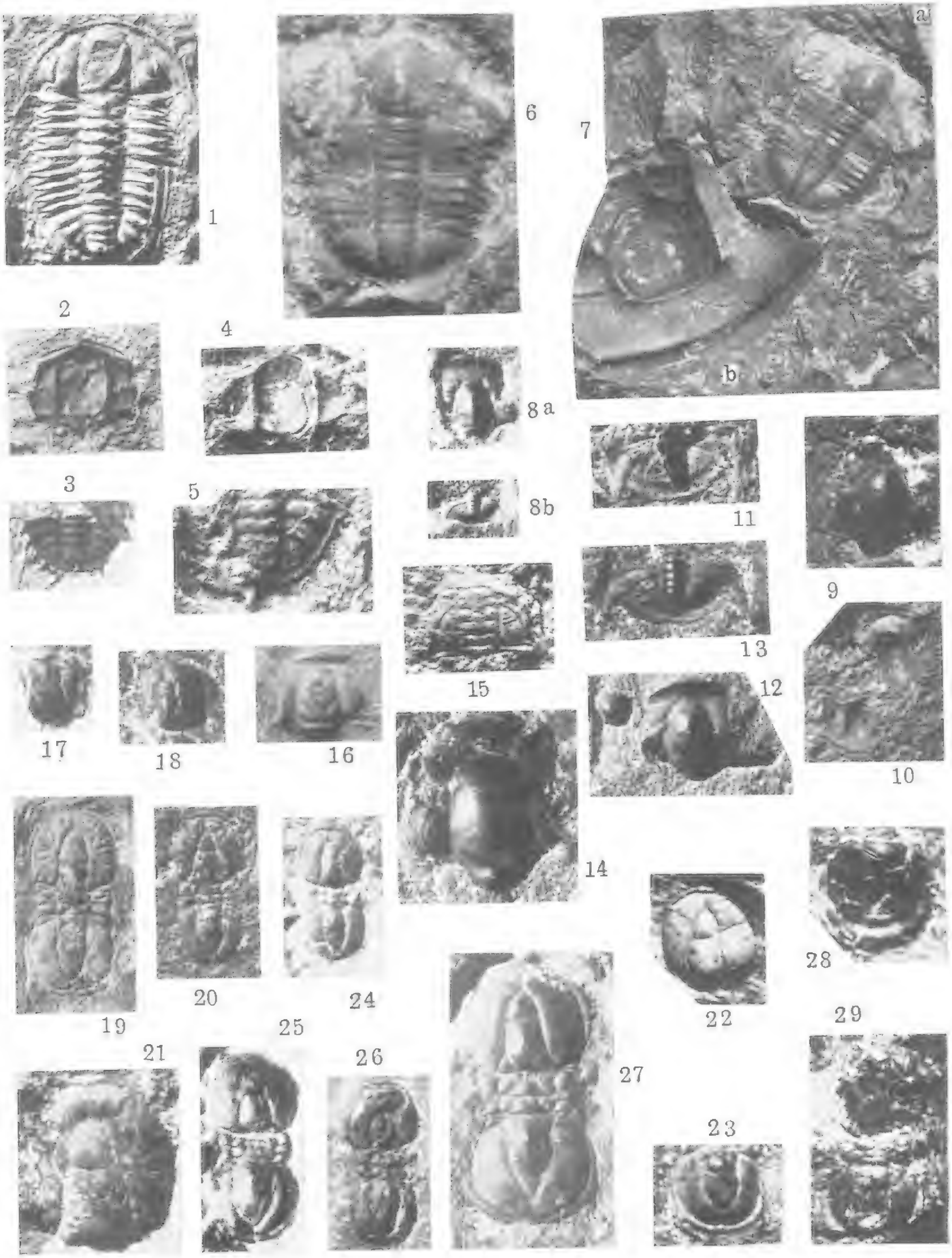

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A CENTRAL QUEENSLAND WOMBAT.

By H. A. Longman, Director.

(Plate XXVI.)

In July, 1937, a single specimen of a large male wombat was collected for the Queensland Museum by Messrs. Charles and H. Greensill Barnard at Epping Forest Station, 75 miles west of Clermont. Special collecting trips were undertaken by these naturalists, who had heard of the existence of large wombat-like animals in that district.

Although these marsupials were widely distributed in Queensland in the Pleistocene and two present-day species were known to occur sparingly in southern parts of the State, it was somewhat surprising to have definite evidence of living wombats in a locality in central Queensland. This extends their range by over 400 miles.

This Epping Forest wombat is obviously of the *latifrons-gillespiei* type, generically designated as *Lasiorhinus.* It is here described as a new subspecies—*Lasiorhinus latifrons barnardi.*

Description.—The pelt, which was received with a complete skull and limb bones, is slightly over four feet in maximum length (Reg. No. 6239). The texture of the fur is somewhat silky as in *latifrons* and *gillespiei.* The rhinarium is completely clothed with short, close hairs. The ears are of the elongated type (incomplete in this pelt), being over 60 mm. in length.

General dorsal colour brown, but mottled with grey, interspersed here and there with entirely black hairs. Basal portion of dorsal hairs dark brown. Rhinarium hairs brown. Tufts of white hairs around the outside of the ears. Outside of ears well haired, but inside sparsely clothed. Ventral surface dirty grey, gradually merging into dorsal colour. Basal portion of ventral hairs dark brown. Feet dark brown. Tail scantily clothed with short dark hairs. Long black hairs are prominent on either side of the sacral region, in the median area of which the hairs are very thick and tufted. Average length of body hairs 25 mm.

Crania.—The skull associated with the pelt has a maximum length of 191 mm. and a basal length of 172 mm. The breadth across the zygomatic arches is 156. The nasals have a length of 77 and a combined breadth at maximum of 67. The length of the palate is 113. The upper molar series, which is well worn, has a length of 57·5 mm. The skull is evidently that of a fully mature wombat. The post-orbital processes, typical of *Lasiorhinus,* are very rugose and this characteristic also applies

to the region over the orbits, the lachrymal, and the maxillary area adjoining the nasals. There is a slight anterior projection of the frontals in the median line between the nasals. A prominent projecting knob or nasal spine (bifid) is present on the premaxillaries. The lachrymal has a prominent tubercle. The parietal platform is broad. The anterior nares are widely open at their lateral borders, as in typical *latifrons* and the *gillespiei* crania. The anterior edge of each premaxillary is more or less vertical in lateral aspect where it joins the nasals, and there is no anterior projection of the superior border as in *mitchelli*. The relatively wide nasals form practically the whole of the narial roof.

The lower contours of the mandible are markedly convex, as in typical *latifrons*. The length of the symphysis with incisors (84 mm.), exceeds one half of the maximum length of the mandible (154 mm.). The length of the mandibular molar series is 55 mm.

In comparison with the records given by Spencer and Kershaw (1910), the actual dimensions of the skull and the length of the molar series are exceptionally large for an existing wombat.

A second incomplete large skull (No. 6240) was also found near the burrows.

In October, 1937, two additional crania were obtained in the same locality by Messrs. Barnard (Reg. No. 6283-6284). One of these exhibits such a condition of asymmetry that opportunity is taken to illustrate it (Plate XXVI). Evidently development of the left side of the skull was stunted in early life, probably due to hemiplegia. This is markedly shown by the dimensions of the molar series ; that of the right side is 55 mm., whereas the left series only attains 48. The molar series is well worn and the individual evidently lived to maturity. Pathological conditions such as these are apparently very rare among marsupials.

Affinities.—In his comprehensive description of "A New Species of Hairy-nosed Wombat," the late C. W. De Vis[1] recognised the affinities of his *Phascolomys gillespiei* from the Moonie River, south-western Queensland, with the South Australian *latifrons*, but considered that certain cranial characteristics entitled it to specific distinction. Baldwin Spencer and Kershaw, however, in their review of "The Existing Species of the Genus *Phascolomys*" (p. 65)[2] refer to the wide range of *latifrons* and express considerable doubt as to whether De Vis' species is specifically distinct from *P. latifrons*. Iredale and Troughton in their Check List of Australian Mammals (1934) give a generic name "Wombatula" for De Vis' species, but this was done without autoptic examination and no diagnosis was recorded.[3]

[1] De Vis, C. W. Annals of the Queensland Museum, No. 5, 1900.
[2] Baldwin Spencer & J. A. Kershaw. Mem. Nat. Mus., Melb. No. 3, 1910.
[3] Iredale & Troughton, Memoir VI, Austr. Mus. Sydney, 1934.

In his excellent descriptions of the Common and of the Hairy-nosed Wombats, Wood Jones adopts Gray's genus *Lasiorhinus* (1863) for the characteristic South Australian *latifrons* and notes its wide range.[4] The significant structural differences between *latifrons* and *mitchelli* warrant generic distinction.

It is of interest to note that whilst the common naked-nosed wombat was first recorded by Owen from fossil remains and subsequently found as an existing species, the living *latifrons* type has now, conversely, a wider range through records of fossils. Mandibular fragments from the Wellington Valley, New South Wales, were recorded by Owen as *P. latifrons*.

A fairly complete fossil cranium of the *latifrons* type was received in 1917 from Clermont through Mr. Power, Warden of the Mines Department, who thought that it came from Cotherstone, some 35 miles east of Clermont. In this cranium the length of the molar series is 53 mm. and the width of the hind lobe of the second molar is 10·5. This cranium, which is very definitely fossilised, is registered as F. 1279 in our series.

Another fossil skull with mandible attached and with several associated limb-bones, vertebrae and pelvic fragments was found during the excavation of a well at Glengallen Plains, Darling Downs, in 1936. This skull is registered as *L. latifrons* (F. 2526).

Obviously the correct status of existing species of wombats should be considered in association with some of the fossil species, such as *P. kreffti* Owen (1872), *P. medius* Owen (1872) and *thomsoni* Owen (1872). In the paper in which he described *P. angustidens*, De Vis considered that *P. mitchelli* was really distinct from the existing species.[5]

L. Glauert's *P. hacketti* from Western Australia[6] is allied to *P. mitchelli*.

In his Catalogue of Fossil Mammals (1887)[7] R. Lydekker treated Owen's *mitchelli* and *platyrhinus* as distinct species, but in his Handbook to the Marsupialia (1896)[8] he placed *platyrhinus* as a synonym (p. 125).

Owing to the paucity of significant material, the writer has diffidence in attempting a comprehensive revision of the several names that have been given to fossil fragments of wombats. It is evident that these marsupials had a far wider range in the past and that they were decidedly variable. In records of the total length of the molar series in adult crania variations of several millimetres were given by Spencer and Kershaw for both *mitchelli* and *latifrons*.

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[4] Wood Jones, The Mammals of South Australia, Pt. II, 1924.

[5] De Vis, C. W. Pr. Linn. Soc. N.S.W., VI, 1891.

[6] Glauert, L. Rec. West. Aus. Mus. Vol. I, 1910.

[7] Lydekker, R. Catal. Foss. Mamm. Brit. Mus. Pt. V, 1887.

[8] Lydekker, R. Handbook to the Marsupialia, Lloyd's Nat. Hist, 1896.

In the total length of their molar series the new Epping Forest crania are distinctly larger than those of *latifrons* and even of *mitchelli*, but they are much smaller than *P. medius*. Their general facies, however, is so obviously with *L. latifrons* that until additional material is forthcoming it seems best to regard these central Queensland wombats only as a new sub-species.

LASIORHINUS LATIFRONS BARNARDI.

This new sub-species as described above is based mainly on its larger size. As in typical *latifrons* the frontals project slightly between the nasals, whereas in *gillespiei* the nasals project posteriorly into the frontal region. As there is considerable variation in this region it is doubtful whether much significance should be attached to minor deviations of sutures.

The infraorbital foramen is circular or sub-oval, as in *gillespiei* and typical *latifrons*, and not laterally compressed as in *mitchelli*.

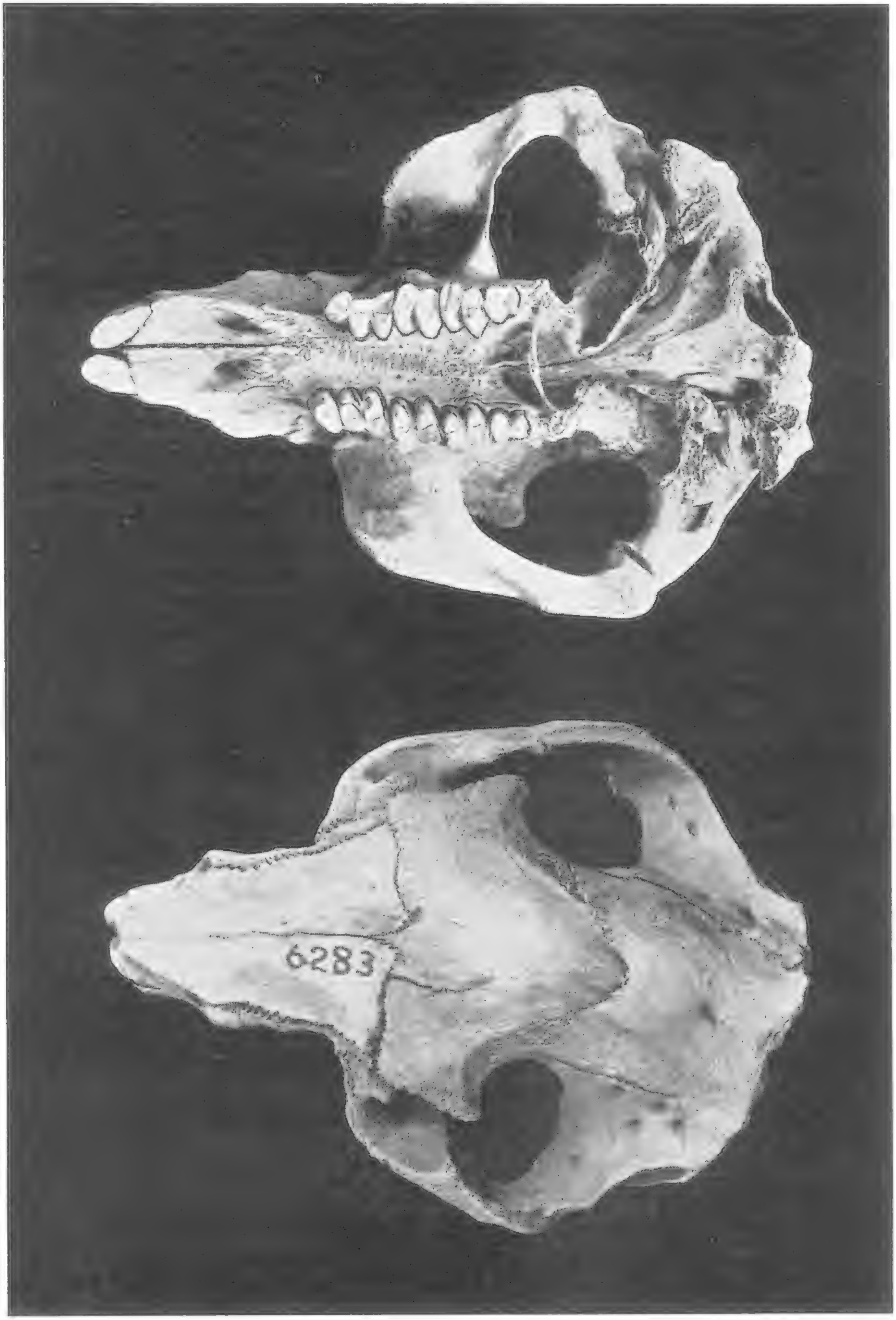
Messrs. Barnard record that the total length of the animal as measured when shot, was 3 feet 4 inches, with a girth of 2 feet 8 inches. The length of the diminutive tail was $2\frac{1}{4}$ inches. The eyes were brown in colour.

In view of the variation in colour recorded for species of wombats the differences between *gillespiei* and *latifrons* are not very significant.

The two skins, male and female, received by De Vis from Bullamon Station, on the Moonie River, show that the *gillespiei* form was very variable. The cranial distinctions noted by De Vis such as the development of the lachrymal protuberance and of the nasal spine are not very distinctive characters in this group. Although Owen laid some stress on the direction of the sutures between the frontals and nasals, there is evidently much individual variation in this character. De Vis' species is more reasonably designated to-day as a sub-species—*Lasiorhinus latifrons gillespiei*.

General notes.—Mr. Charles Barnard reports that there were many burrows in the district, but very few tracks of the animals were seen. The Station hands said that the wombats had never been seen far from the burrows, which are in sandy ridges in fairly-well timbered country, but carrying very poor grass. They said that the wombats came out to lie on top of the burrows on very hot days and that they also came out on rainy days. Mr. Barnard notes : " We could see no trace of their feeding out anywhere. They made light pads running from one burrow to another. The burrows were generally not more than one hundred yards apart and were mostly in groups of three or four."

Only three animals were seen, one of which was shot. As suggested by Messrs. Barnard, it is probable that these wombats were much more numerous in earlier



H. A. Longman.

years, but successive periods of drought have brought them to the verge of extinction. It was considered that these wombats obtained most of the food underground. Although they may be partly rhizophagous, the examination of stomach contents of the specimen shot (thoughtfully preserved by Messrs. Barnard) shows that this particular animal had been feeding on " the above ground parts of plants." We are indebted to Dr. D. A. Herbert for examination of this material, which consists largely of fragments of stems and leaves, including awns of the Comet River Grass, *Perotis rara.*

It is of interest here to record that Mr. Griffiths of the Monkland School, Gympie, informed me that about twenty years ago (from August, 1937) he saw wombats " distinctly " in the Tambo district.

The Common Wombat, *P. mitchelli,* extends into the southern portion of Queensland in the Stanthorpe district, from whence several specimens have been obtained in recent years. Iredale and Troughton (1934, p. 34), following Mathews and Iredale (1912, p. 14),[9] designate this species as Perry's *hirsutum,* but it seems more probable that the wombat illustrated by Perry and named *Opossum hirsutum* came from a Bass Strait island and should be kept in the synonymy of *ursinus.*

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[9] Mathews and Iredale, Vict. Naturalist, Vol. XXIX, 1912.

A BICEPHALOUS SNAKE.

By H. A. Longman, Director.

(Plate XXVII.)

In September, 1938, we received a specimen of a bicephalous snake from Mr. J. P. Forbes, of Mullumbimby, New South Wales, with the information that it was obtained about sixteen years ago.

As this is the first local record of a bicephalous snake known to the writer, it has been thought worthy of brief notice.

The snake is obviously a young specimen of the Common Black Snake *Pseudechis porphyriacus*. As it is only ten inches (250 mm.) in maximum length, it is doubtful whether it lived to feed, as it is approximately the length and size of Black Snakes at birth. Almost immediately behind the head the two anterior regions are united to a single body, and the scales are numerous and irregular in this region. A short distance posteriorly, however, the normal series of seventeen body scales may be counted. There are no special peculiarities to be noted in either of the two heads and the lepidosis of the posterior part of the body is normal. As the specimen has been preserved for so many years, it seems undesirable to make dissections.

In 1925 J. Strohl gave records of sixty-eight instances of this abnormality.[1] J. Miguel Ladeiro in 1935 illustrated with a radiograph a specimen of *Tropidonotus natrix* in the Coimbra Museum.[2]

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[1] 1925. J. Strohl, Ann. Sci. Nat. Zool., 8, pp. 105-132.

[2] 1935. J. Miguel Ladeiro, Mem. Estudos Mus. Zool. Univ. Coimbra, Ser. IV, No. 2.

A Bicephalous Snake.

ABORIGINAL MIDDENS OF POINT CARTWRIGHT DISTRICT.

By G. K. Jackson.

(Figures 1–7.)

On many parts of the Queensland coast, old aboriginal camping grounds with the usual supply of shells and stone chips occur at intervals at places suitable for such a purpose, and regulated, of course, by the supply of food and water in the locality.

Between Point Cartwright at the mouth of the Mooloolah River and Lake Garrimundi just to the north of Caloundra there occurs a stretch of uninhabited coast, consisting of a line of sand dunes backed by a large plain or boronia swamp, stretching west to the Mooloolah River. In the folds of these sandhills, a number of fine kitchen middens are located. During the years 1932 to 1934, several of these were in excellent condition, appearing as though they had only recently been abandoned. However, at the beginning of the year 1938, they were found to be suffering from the effects of heavy seas which, during the winter months, had swept far up into the sandhills.

These old camping grounds lie within the rich territory formerly inhabited by the Kabi tribe, and formed bases periodically visited during their nomadic wanderings.

The camps occur only among those sandhills which are devoid of trees, one reason for this being that they were less likely to be disturbed there by a hostile party, while sleeping off the effects of a feast of rich coastal food. The enemy naturally would find it hard to creep upon a camp situated in the centre of an extensive white sand dune. Another point in favour of these positions is the absence of mosquitoes and sandflies in the summer months, which would not be the case in amongst the low scrubby vegetation of the timbered sandhills.

Fresh water is abundant even when the swamps are suffering from a spell of drought, and the blacks had only to dig a foot or more into the sand at the base of the depressions on the western side of the dunes to obtain a plentiful supply.

In an examination of one of these middens the most striking feature is the quantity of " eugarie " shells (*Donax deltoides*), Q.E. 3302, spread about the sand.

This shell-fish formed a large item on the menu of the coastal blacks, and was obtained in the surf at low water by digging with the foot. A curious point to observe is the fact that the shells are more or less of a uniform size; neither the very small nor the very large ones appear to be present. Possibly the larger ones lacked the flavour of those of medium size, or else overfishing had prevented full development. This is rather an interesting point in view of the fact that many of the large middens on Stradbroke Island are filled with shells of maximum size.

Being a bivalve the " eugarie " was opened by being subjected to heat alongside a small fire. This accounts for the fact that the shells are nearly all in perfect condition, only showing the results of weathering during the time they have been lying around the sandhills.

Apart from utilising the flesh for food, the Aborigines used the shells of these animals as planes and scrapers for smoothing boomerangs and spears, and for reducing the latter to a sharp point, just as the more inland blacks used the fresh water mussel shell.

Passing from the shell deposits, we next turn to the stones and rocks which have been carried to this area for the purpose of manufacturing various implements. The largest are the grinding and pounding stones which are perhaps the most local in origin. They are made from the same rocks which form most of Point Cartwright and Moffats Head to the North and South of the area respectively, that is various grades of sandstone ranging from a very fine-grained variety up to a fairly coarse grit. They were apparently carried along the miles of beach to their present location by the unfortunate women.

The variety of stones other than these is very extensive. The commonest is quartzite of various kinds, this rock being excellent for the making of knives, scrapers, etc. We find also trachyte, granite, hornblende-porphyrite, flint, quartz, opal, agate and petrified wood.

Amongst other implements used extensively in this district by the Aborigines were those associated with the preparation of fern root for food. The fern, *Blechnum serrulatum*, known to the blacks as " bungwall," is very common in all coastal swamps. It possesses a thick rhizome growing perpendicularly in the soil. This was dug up by the women with the aid of yam sticks, or by hand, after which it was cleaned and roasted in hot ashes. Then came the chopping-up process, with the aid of a stone implement, specially suited for this purpose. The root was placed on a log or piece of wood, and the chopper held in one hand. After having been reduced to small pieces, it was either eaten thus or else further ground and pounded on grinding stones, then mixed with a little water and made into small cakes. It was apparently a very nourishing food.

The chopper used for this purpose is an implement of quartzite or some other suitable rock, flaked away on one margin after the style of a chisel, and possessing secondary chipping along its edge. Figs. 1, 2 and 3.

Mr. N. B. Tindale, of the South Australian Museum, informs me that these implements are similar to a characteristic type found in Southern Australia, and belong to the same type as the " Sumatra implements " of the Malay Peninsula. They have not previously been recorded from Queensland.

A similar implement collected by myself at the Piccabeen Lakes, Northern New South Wales, in 1930, gives an idea of their coastal distribution both north and south of the Moreton Bay Area.

This specimen is of red quartzite and the edge has been formed by the removal of two large flakes, and shows distinct polishing along either face. The back in this case has been flaked to form the usual rounded hand grip.

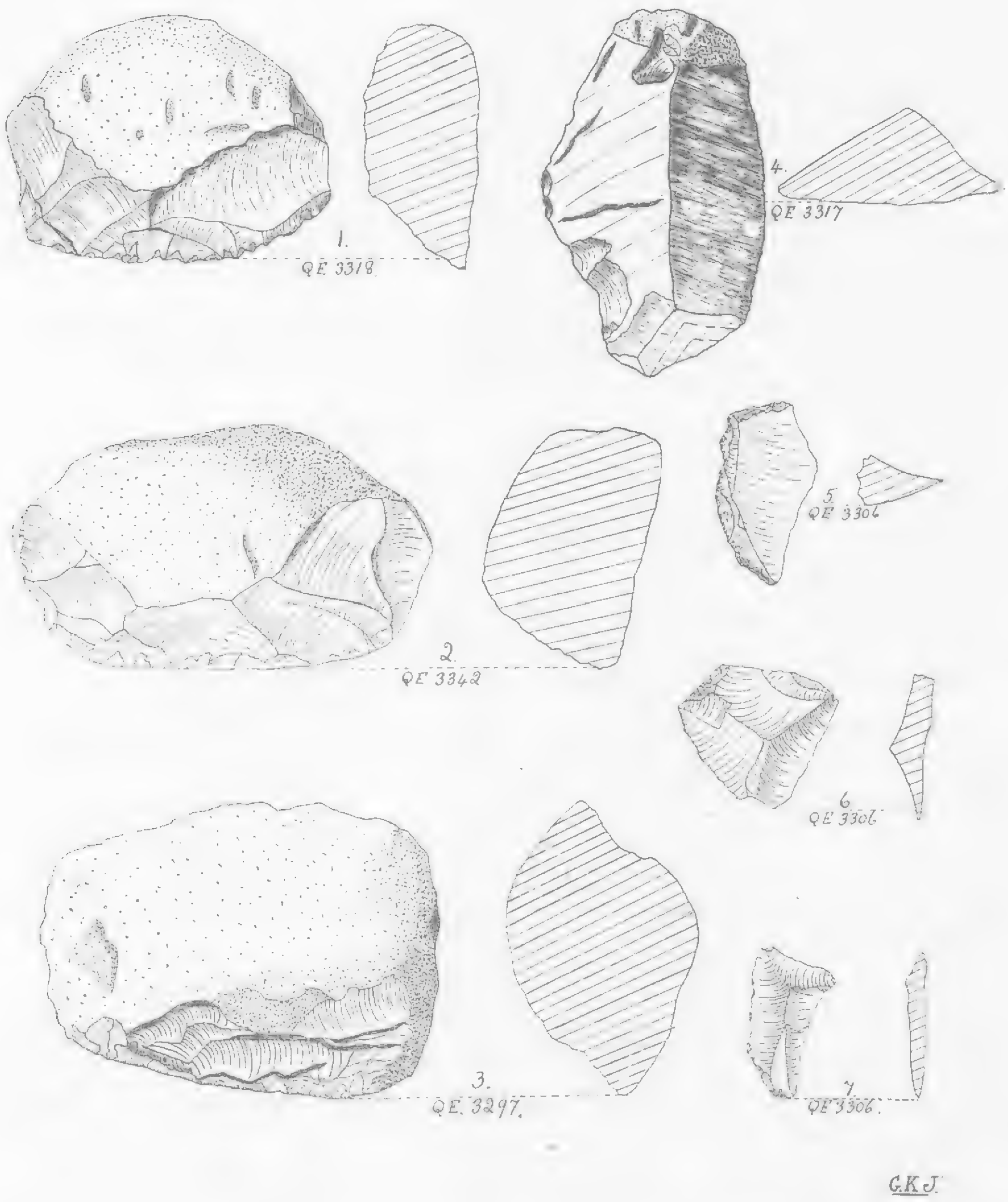
Several miles to the westward of these sandhills lies the Mooloolah River, and I am indebted to Mr. W. Potts, of Mooloolaba, an old pioneer of the district, for showing me some further native middens along portions of its bank. They were composed of piles of oyster shells, sometimes rising in the bank to a height of seven feet above the river.

Mr. Potts informed me that the blacks used to dive for oysters, either from the bank or from their canoes: native name " Kumbur " (" The Australian Race," E. M. Curr, Vol. III, p. 143), made from the bark of swamp mahogany trees. The oysters, of course, grew on the bed of the river. One can easily pick the parts where they are most abundant, as nearby are numerous shells. In barren portions of the river, the banks are likewise barren of shells.

After a spell of coastal food the Aborigines, probably at the suggestion of some old man, would move camp and journey up into the rain-forests of Buderim Mountain or some other locality, and so they travelled from place to place, as the instinct or the call for change of food prompted them.

An interesting feature of this area, which has disappeared through denudation within the past few years, was the presence of rock carvings or " peckings " on the shore-platforms of Pt. Cartwright and Moffats and Wickham Heads.

In the year 1932 quite a number were still in existence but the alternate wetting by sea water and sun drying caused the sandstone to flake away, eliminating all trace of these relics. They must at one time have been very extensive. These rock carvings showed emu and kangaroo footprints, and also those of a variety of smaller birds. Dingo footprints were a fairly-common feature. I was lucky enough to see one quite good " pecking " of a human footprint. Other markings of an indefinite character occurred, but some of these were very vague.



Figs. 1-7.—Implements from Point Cartwright Middens.

LIST OF SPECIMENS.

Fig. (1) Q.E. 3318.—A chopper for " bungwall " fern. In size 91 mm. x 73 mm. x 41 mm. Composed of a water-worn quartzite pebble, which has been reduced to a chisel edge on one side by flaking. It shows secondary chipping and flaking and possesses a good chopping edge.

Fig. (2) Q.E. 3342.—Another " bungwall " chopper, showing considerable use, the cutting edge being rounded off by continuous pounding. In size 120 mm. x 67 mm. x 55 mm. Composed of quartzite it is very weathered on its original surface. It shows good flaking and secondary chipping and has the same chisel edge as the former specimen.

Fig. (3) Q.E. 3297.—Chopper of quartz, which is very interesting in view of the fact that it possesses two cutting edges on opposite margins. Both are well worn and show flaking and secondary chipping. It is 120 mm. x 52 mm. x 60 mm. in size.

Q.E. 3307—Unfigured Specimen.—Another chopper made from a quartzite pebble which has been reduced to a good edge by the striking off of one large flake. It too possesses a good chopping edge. Size 70 mm. x 70 mm. x 30 mm.

Fig. (4) Q.E. 3317.—A stone knife of quartzite. Native name " dhak-ke." Size 101 mm. x 63 mm. x 24 mm. This specimen is well shaped and possessses two good cutting edges, one of which shows secondary chipping.

Fig. (5) Q.E. 3306.—This specimen is rather a fine example of a chipped back scraper 51 mm. x 29 mm. It is made of flint and shows secondary chipping. The single cutting edge has apparently been subjected to much use.

Fig. (6) Q.E. 3306.—A scraper or knife 41 mm. x 46 mm. Made of fine-grained grey quartzite. Shows secondary flaking and possesses two fine cutting edges.

Fig. (7) Q.E. 3306.—A small scarifier of mottled pink quartzite 43 mm. x 22 mm. This specimen shows secondary chipping and flaking, and possesses two good cutting edges. The blade is distinctly curved to one side.

UNFIGURED SPECIMENS.

Q.E. 3306.—A small scraper 25 mm. x 23 mm. made of common opal. Shows secondary flaking and possesses one cutting edge.

Q.E. 3306.—A side scraper showing secondary flaking 41 mm. x 33 mm. Composed of fine-grained grey quartzite, weathered on two original faces. Possesses two cutting edges.

Q.E. 3306.—A small spokeshave or chisel of flint 48 mm. x 33 mm. Possesses grooved cutting edge at broad end, formed by a large conchoidal fracture in the stone. Secondary flaking is noticeable.

Q.E. 3306.—A small flake scraper made of fine-grained grey quartzite 30 mm. x 25 mm. Possesses one cutting edge.

Q.E. 3306.—A small high-backed scraper 35 mm. x 27 mm., made of grey quartzite. Shows good flaking and possesses one cutting edge.

Q.E. 3306.—A rather fine scraper or knife, made of quartzite 61 mm. x 45 mm. Slightly discoloured by iron staining. Shows secondary chipping and flaking. It possesses three cutting edges.

Q.E. 3306.—A high-backed scraper 38 mm. x 32 mm. Composed of grey quartzite slightly weathered on its outer extremities. Possesses three good cutting edges and shows secondary flaking.

Q.E. 3306.—Another quartzite scraper, 43 mm. x 42 mm. Shows secondary flaking and possesses three cutting edges.

Q.E. 3306.—A fairly well-shaped scraper of fine-grained grey quartzite, 40 mm. x 43 mm. It, however, shows very little secondary working. Possesses one cutting edge.

Q.E. 3306.—A knife of quartzite, discoloured by oxidation, 45 mm. x 33 mm. It is rather well shaped and possesses two cutting edges showing fair use.

Q.E. 3306.—A knife or scraper of silicious rock 58 mm. x 38 mm. Shows secondary flaking, and possesses one good cutting edge.

Q.E. 3306.—A high backed side scraper of grey quartzite, 41 mm. x 31 mm. Shows secondary flaking and chipping and possesses a good cutting edge.

Q.E. 3306.—A rather more irregular type of scraper 36 mm. x 41 mm. Made of grey quartzite, slightly discoloured by oxidation. It possesses three cutting edges, two of them showing much wear.

Q.E. 3306.—Apparently a knife which has been broken during process of manufacture, 41 mm. x 35 mm. Composed of a grey rather coarse quartzite. Shows secondary chipping and flaking and possesses two cutting edges.

Q.E. 3306.—A small scraper 36 mm. x 30 mm. Made of fine-grained grey quartzite. Shows rough flaking, but has a rather unfinished appearance. Possesses three cutting edges.

Q.E. 3306.—A small scraper 35 mm. x 20 mm. with a chisel edge at one end. It is composed of a fine-grained grey quartzite and shows secondary flaking. It possesses two cutting edges.

Q.E. 3306.—A large implement of quartzite stained by iron, 75 mm. x 57 mm. Possesses only primary flaking, but one cutting edge shows considerable use. It was probably used as a chopper for cutting up " bungwall " fern root.

Q.E. 3306.—A simple knife of quartzite 75 mm. x 42 mm. Made from a single flake struck from a water worn rock. Its single cutting edge shows much wear, and it too was probably used for cutting " bungwall " root.

Q.E. 3306.—A small scraper of common opal 32 mm. x 17 mm. It is rather a crude implement, and has one poor cutting edge.

Q.E. 3306.—A scraper of quartzite 56 mm. x 32 mm. Has one rather rough cutting edge. Only a little rough flaking is visible.

Q.E. 3306.—A knife formed of quartzite, struck from a water-worn stone, 61 mm. x 24 mm. Has two cutting edges, and shows a little secondary chipping.

Q.E. 3306.—A scraper or knife of quartzite also stained brown by oxidation, 63 mm. x 44 mm. Shows secondary flaking and possesses two good cutting edges.

Q.E 3299.—An upper grinder of trachyte. In size it is 104 mm. x 104 mm. x 61 mm. and possesses much secondary flaking. It was used in conjunction with the large sandstone grinders for milling " bungwall " root.

Q.E. 3300.—This implement is composed of trachyte with a badly-weathered surface, indicating extreme age. It is apparently a stone axe in the making and shows good flaking and secondary chipping. Size 105 mm. x 87 mm. x 46 mm. It was evidently discarded for some reason or other before completion.

Q.E. 3284.—A lower grinding stone, composed of a fairly fine-grained grey grit. Size 9½″ x 8¼″ x 3¼″. It possesses fairly deep grinding hollows on both sides.

Q.E. 3282.—A lower grinding stone composed of a fine uniform-grained grey sandstone. Size 8¼″ x 8″ x 3¾″. This also possesses fairly deep ground-out hollows on both sides.

Q.E. 3286.—A triangular-shaped lower grinding stone composed of a fairly fine-grained grey sandstone. Size 9″ x 8½″ x 2¼″. It has had very little use, and the hollow on one side is quite shallow.

Q.E. 3285.—Portion of a grinding stone composed of a fine uniform-grained grey sandstone. Size 8″ x 9″ x 3¼″. This one has apparently been used for the purpose of sharpening axes and other tools, as the groove is wider and larger in extent than that observed in other specimens. It is grooved on both sides.

Q.E. 3287.—A lower grinding stone composed of a very fine-grained grey sandstone. Size 8″ x 5¾″ x 3¼″. The groove in this one is fairly shallow and appears on one side of the stone only.

Q.E. 3294.—Fragment of a lower grinding stone composed of a coarse uneven grained sandstone. Size 6″ x 5¼″ x 2¼″. It has presumably been broken early in its use as there is little sign of wear on the grinding surface.

Q.E. 3292.—Half of a lower grinding stone composed of a coarse sandstone. Size 6¾″ x 6½″ x 2½″. It possesses a good worn groove on one side only. This specimen is badly weathered, and has probably been lying there for a considerable period.

Q.E. 3292.—A small lower grinding stone, composed of a fairly coarse-grained sandstone, containing limonite, which has at some time been deposited into hollows in the rock. Size 6½″ x 5½″ x 3¼″. It is ground out on one side only.

A NEW FISH, OF THE GENUS *PRIONOBUTIS*, FROM NORTHERN AUSTRALIA.

By Gilbert P. Whitley, F.R.Z.S.,
Ichthyologist of The Australian Museum, Sydney.

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Family ELEOTRIDAE.

Genus **PRIONOBUTIS** Bleeker, 1874.

Prionobutis Bleeker, Arch. Neerl. Sci. Nat. ix, 1874, pp. 295 & 305. Orthotype, *Eleotris dasyrhynchus* Gunther, Ann. Mag. Nat. Hist. (4) i, April 1, 1868, p. 265, pl. xii, fig. B, from Sarawak. *Id.* Bleeker, Arch. Neerl. Sci. Nat. x, 1875, p. 103 and Versl. Akad. Amsterd. (2) xi, 1877, p. 73 (*fide* Weber & de Beaufort, 1911). *Id.* Herre, Gobies Philip. & China Sea, 1927, p. 52. *Id.* Koumans, Zool. Mededeelingen xx, 1937, p. 21. *Id.* Fowler, Proc. Acad. Nat. Sci. Philad. lxxxix, 1937, p. 248.

A genus of small gudgeons found in marine, brackish, and fresh water in the Indo-Australian and southern Asiatic regions, whence a few species have been described. A characteristic feature is the presence of rows of spines on the top of the head. Two subgenera may be distinguished:

A. Eye small, about 8 in head. Mouth reaching backward to behind level of eyes .. *Prionobutis* (type, *dasyrhynchus*).

AA. Eye large, less than 4 in head. Mouth reaching to below anterior half of eye .. *Themistocles*, subg. nov. (type, *wardi*, nov.).

PRIONOBUTIS (THEMISTOCLES) WARDI, subg. et sp. nov.

(Figure 1.)

D. vi/i, 8; A. 8; P. 17; V. 5; C. 12 et lat. brev. Sc. 26 to hypural. Tr. 9, below first dorsal, to 5 on caudal peduncle. About 9 predorsal scales.

Head (13 mm.) 3·15, depth of body (11) 3·7, length of pectoral (12·5) nearly 3·3, depth of caudal peduncle (5) 8·2 in standard length (41 mm.). Eye (4 mm.) 3·25, interorbital (3) and snout (3) 4·3 in head.

Head blunt, longer than broad or deep. Lower jaw slightly longer than upper; mouth extending to below anterior half of the large eye. Fine teeth in jaws, outer ones slightly enlarged, but no canines. Tongue rounded. Eyes dorso-lateral, armed above and behind by a row of about two dozen small spines. Some similar spines above the nostrils and on each side of the premaxillary processes which reach back almost to level of eyes. A few more spines scattered on nape and along the sides of the distinct nuchal groove. Preoperculum entire, unarmed, its limb with a few open pores. Operculum entire, ending in a flap with a blunt spine. Cheeks and opercles scaly. Top of head scaly from a little behind the eyes. Interorbital flat and sunken. A

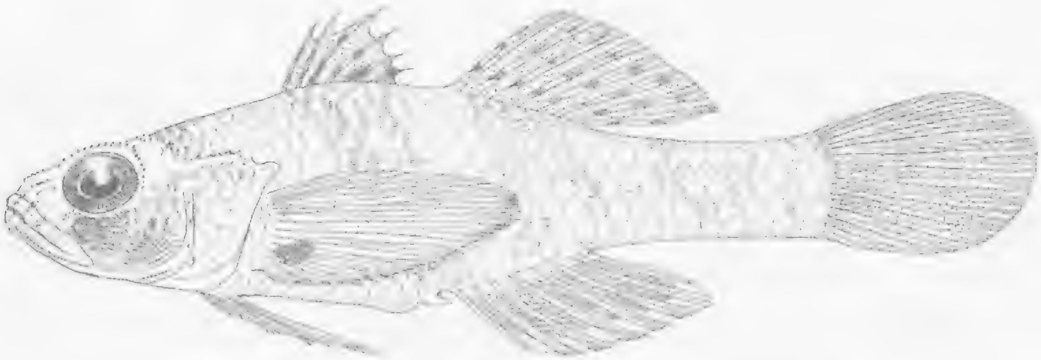

Fig. 1.—*Prionobutis* (*Themistocles*) *wardi*. (G. P. Whitley.)

row of fleshy papillae along each side of lower surface of head. No cuticular papillae elsewhere (but a paratype has some short rows of minute papillae on cheeks). A small mental flap at the symphysis of the lower jaw. Gill-membranes united across the tapering isthmus. Body compressed, deep below the first dorsal fin and tapering to a long caudal peduncle, covered with large thin ctenoid scales which do not extend on to fins. No auxiliary scales. Vent large. A large genital papilla.

First dorsal fin with six weak spines. Second dorsal short-based but with long rays. Anal fin similar to second dorsal. Pectorals long, extensive, ninth ray longest, reaching anal fin; lower rays fringe-like. Ventral fins well separated, inserted well forward; rays weak, fringed. Caudal rounded, upper half the longer.

Colour in alcohol, rich brown; ground-colour of fins somewhat yellower. Head and body crossed by several diffuse bands of darker-edged scales. The first dark area crosses the cheek, two bands extend from first dorsal to near

V

the belly, another band below soft dorsal breaks into two on lower half of fish over the anal fin, two or three more dark transverse areas across caudal peduncle. Eye bluish. Top of head yellow. Fins speckled and mottled with dark brownish. Caudal largely dusky (often light or only partly infuscated in paratypes).

Described and figured from the holotype, a specimen 41 mm. in standard length or two inches overall, the largest of a series of ten specimens.

Localities.—Off Point Charles, near Darwin, Northern Territory of Australia; caught in tangled rope in 12 fathoms, June 1938. Holotype (Austr. Mus. regd. no. IA. 7849).

Same locality, July 4, 1938. Paratype, IA. 7850.

Darwin Harbour, near the jetty, 8 to 10 faths., July 30, 1938: six paratypes (IA. 7852-3), and one (IA. 7610) in burrows on mud-flat, Darwin, July 31.

Off the south coast of Melville Island, Northern Territory, 8 to 13 faths. July 1938: one paratype (IA. 7854). Specimens caught in rope tangles from H.M.A.S. "Moresby" by Mr. Melbourne Ward, naturalist to the naval surveying expedition, after whom I gratefully name the species.

Range.—Northern Australia; Dampierian marine region, shallow water.

This new species differs from the genotype in having much larger orbits, and maxilla reaching to below, not behind, the eyes. From the other species (*koilomatodon* Bleeker, 1849; *caperatus* Cantor, 1850, *serrifrons* Rutter, 1897) it is distinguished by the form of the head and in having papillae on chin. *Pogoneleotris microps* Weber, 1908 is nearer the small-eyed *Prionobutis dasyrhynchus* (Gunther, 1868) but has auxiliary scales on the body.

END OF Vol. XI. *MEMOIRS OF THE QUEENSLAND MUSEUM.*

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